Electrical Review

VOL. 26. No. 7.
WEEKLY.

NEW YORK, WEDNESDAY, FEBRUARY 13, 1895

VIEWS, NEWS AND INTERVIEWS.

"A friend of mine invented a very ingenious gas appliance and wanted to test it in my office," remarked a Wall street broker. "I discovered that there was no gas in my building and we had to inquire in buildings over two blocks down Wall street before we found a gas burner in working order. The incandescent lamp has made great progress, surely."

Mr. Nikola Tesla is generally regarded as an unusually modest man, and one who doesn't go in for ostentatious display. This was exemplified at the time the New York *World* printed an interview with him, written by Arthur Brisbane and accompanied by that truly marvelous picture of Tesla, showing him standing erect with lightning flashes glancing out from every portion of his body. Mr. Tesla had gone to a well-known health resort for a brief vacation a few days prior to the publication of the interview. He had been at the hotel just long enough to make a few acquaintances, and to become pretty well known himself. On the Sunday that the interview was published, the papers containing it reached the hotel at 10 o'clock. Mr. Tesla, in walking about the hotel lobby, observed many people who glanced at a paper in their hands, then looked up at him with an expression of awe, and finally put their heads together and discussed something in whispers. He finally discovered the cause to be that wonderful picture. At 11 o'clock Sunday morning Mr. Tesla was on the first train bound for New York.

The telephonic communication between Berlin and Vienna, which was opened on December 1, has not met with expectations. The sounds are almost inaudible and Vienna papers claim to be able to prove that the trouble lies in the defective instruments used in Berlin.

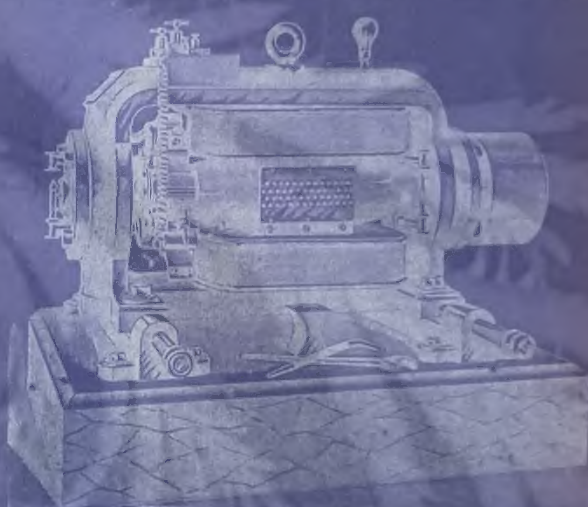
At a recent meeting of the German

instead of platinum. The co-efficients of expansion by heat of aluminium and glass being very different, special means have to be adopted to secure a tight joint. The plan adopted is as follows: A wire of aluminium is placed in a glass tube and heated until both it and the glass fuse. The aluminium core and its glass jacket thus produced are allowed to cool, when the latter cracks, but this is of no importance, as the object of this jacket is simply to prevent the aluminium melting when it is being soldered on to the thick envelope which is to form the base of the lamp. This having been done and the filament fixed, the bulbs are exhausted, a drop of a strong solution of mercuric chloride having been previously placed on the outer ends of the leading-in wires. As the vacuum is formed in the bulb, this solution is drawn in past the aluminium wires. These latter then first become amalgamated and then oxidized and the alumina thus formed is said to lute up the wires perfectly air-tight.

In response to resolution the railroad commission reports the increase of capital stock by railroads in New [illegible]

The Lindner Dynamo.

The illustration presented herewith is from London *Industries and Iron* and shows the Lindner dynamo, made by the Elektro-Mekaniska Aktiebolaget Norden, of Stockholm, Sweden. This machine embodies several differences in design from the usual dynamo type. It will be seen that there are no special brackets, etc., for supporting the bearings, which are supported in cylindrical openings in the frame itself. The whole of the iron in the frame, therefore, is utilized to form the magnetic system, thus performing a two-fold duty. The lubrication is entirely automatic, and is effected by a device which allows oil to flow from receivers in the body of the cylinder in which the bearings are fixed, and the same oil is continually used until its lubricating properties are exhausted. The quantity and quality of the oil can be inspected at any time by means of gauge glasses, and renewal is usually required only once a fortnight. These dynamos are made either series, shunt or compound wound. It is claimed that there is no sparking at the commutator, and that the brushes require practically no shifting for any load.



The Lindner Dynamo.

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TESLA'S LABORATORY BURNED.

THE DISTINGUISHED INVENTOR'S HEAVY LOSS BY FIRE OF APPARATUS AND RECORDS.

By a fire which almost completely destroyed the six-story and basement building at 33 and 35 South Fifth avenue, New York city, March 13, Nikola Tesla, the electrician, lost all of the apparatus with which he has been carrying on his professional experiments. Mr. Tesla occupied the entire fourth floor. When the floor gave way his apparatus fell to the second floor, where it remained in an unrecognizable ruin. It was not insured.

Mr. Tesla was naturally considerably affected by this sudden and most disastrous loss, but with true grit at once began preparations to resume his work elsewhere. In an interview he says:

I am congratulating myself all the time it is no worse. I begin all over again, but I have the knowledge and experience of what has gone before, and fortunately I was able to show with completed apparatus that my ideas and theories are correct. Had the fire occurred a few months ago, I should have been robbed of the opportunity of many highly successful demonstrations. Take my oscillator, for example, that combines the steam engine and dynamo. Last Fall, for example, I had there a gathering of medical and other professional men—perhaps 200—and they all saw the machine running, lighting up my laboratory with plenty of lights and furnishing current for a series of novel experiments. The machine is gone. But suppose the fire had happened

fected machine, but which, of cours suggests many new lines of though every day. Another was improve methods of electric lighting. An other was the transmission of intell gence any distance without wires. fourth, which is an ever present prob lem for every thinking electrician touches the nature of electricity Each of these questions and man others I shall follow up, and someho I cannot help feeling that this dis aster will sharpen my intuition as t the best lines of work, so that goo will come out of evil. With so much on my mind and hands I need no excuse myself for being brief with you. I have been overwhelmed with generosity and sympathy this week and feel the kindness deeply, even i I can make no response. But I must carve my way through or over the mountain suddenly planted in front of me, and so you see me preoccupied. I am glad to add to-day that by last reports from the scene of the fire some of the debris is in better shape than I dared hope, and I may yet see some valuable salvage. But my men are meantime busy as though none of the old were left.

A Swiss Electric Railway Project.

Swiss electrical engineers seem to be bent on showing to the world what feats can be accomplished with electric motors. Witness the latest project of an Alpean electrical railway proposed by La Compagnie de l'Industrie Electrique of Geneva. It is

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Fall, for example, I had there a gathering of medical and other professional men—perhaps 200—and they all saw the machine running, lighting up my laboratory with plenty of lights and furnishing current for a series of novel experiments. The machine is gone. But suppose the fire had happened before that or before others had seen it running? My statements about it would not have been half so convincing. Everything is destroyed—practically all—although, of course, where some of it has passed into commercial operation the interest in that part was of an historic and personal nature. I had a cabinet containing many of the earlier inventions, over which I have brooded and worked days and nights. To-day the ideas there embodied are utilized in the big 5,000 horse-power generators at Niagara and in kindred motors in a great many parts of the world; but I prized the old models and trial apparatus, and would not have taken any money for them. Some of them were shown in the Electricity building at the World's Fair, where also some of the new principles I have discovered were illustrated by operative devices. These devices I had in my laboratory, and they have gone down in the wreck, too. Moreover, I had there some records, books and papers, such as every industrious experimenter is likely to get around him in time, and they have vanished. Happily, a good deal of my work has appeared in book form now, or in the technical journals, and that much is secure. The rest, he added, with just a little note of sadness in his voice, I shall try to jot down as soon as I can get time from more pressing matters. You know an inventor while making experiments often gets a few spare minutes between whiles, and I had been employing some of these spells lately in getting my data in better order. Part of that work has gone also.

I was engaged on four main lines of work and investigation. One of these was the oscillator, which I cannot but regard as a practically per-

FIG. 2.—INTERIOR
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planned to connect Zermatt, Go grat and Mount Cervin. Star from the Zermatt depot, the Gor grat road is to be constructed a the Winkelmatt on the right ban the River Viège; thence ascen through the forests to the Hotel delen, on the Riffel Alp, it will towards Mount Riffel, and gain Gornergrat at an altitude of 10, feet above the sea level.

The necessary motive power i be derived from four rivulets, the Findelenbach, Toeschbach, Z bach and Fürggbach. It is estima that 600 horse-power is needed

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 (N.Y.)

fected machine, but which, of course, suggests many new lines of thought every day. Another was improved methods of electric lighting. Another was the transmission of intelligence any distance without wires. A fourth, which is an ever present problem for every thinking electrician, touches the nature of electricity. Each of these questions and many others I shall follow up, and somehow I cannot help feeling that this disaster will sharpen my intuition as to the best lines of work, so that good will come out of evil. With so much on my mind and hands I need not excuse myself for being brief with you. I have been overwhelmed with generosity and sympathy this week, and feel the kindness deeply, even if I can make no response. But I must carve my way through or over the mountain suddenly planted in front of me, and so you see me preoccupied. I am glad to add to-day that by last reports from the scene of the fire some of the debris is in better shape than I dared hope, and I may yet see some valuable salvage. But my men are meantime busy as though none of the old were left.

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Bearing this in mind, and backed by experience and the sound common sense characteristic of the American business man, it seems there is little call for lamentation over present prospects or doubts as to the future.

NIKOLA TESLA.

Tesla's loss by fire, while a serious one, has not prostrated the talented inventor, as the accounts in the daily press imply. Instead he goes to work with renewed vigor, replying to a friend, who suggested that he take a long rest before starting in again, that "I might have followed your advice and taken a rest if this had not occurred, but now I feel that it is about time to stop idling." Tesla never was an idler, and if he works any harder now than before, he will have to find the way to live without stopping to eat or sleep. The kindly tone of the great dailies in speaking of the young inventor's loss is particularly noticeable. We do not remember ever having seen a higher compliment paid anyone than the following from the *Sun* of this city, evidently by Mr. Chas. A. Dana:

> The destruction of Nikola Tesla's workshop, with its wonderful contents, is something more than a private calamity. It is a misfortune to the whole world. It is not in any degree an exaggeration to say that the men living at this time who are more important to the human race than this young gentleman can be counted on the fingers of one hand; perhaps on the thumb of one hand.

The ELECTRICAL REVIEW extends to Mr. Tesla its regrets over his most exasperating loss, but with everyone else interested in scientific progress is glad to note his resolution to at once take up his work so near completion. May health and strength and greater success and honor be his!

April 3, 1895

NIKOLA TESLA'S LOST APPARATUS

ILLUSTRATIONS AND DESCRIPTIONS OF SOME OF THE INVENTOR'S DEVICES DESTROYED BY FIRE—HIS GOOD FORTUNE IN HAVING HAD PHOTOGRAPHS MADE OF THIS APPARATUS MORE THAN A YEAR AGO—THE "OSCILLATOR" AND ITS WONDERFUL EFFICIENCY.

Nikola Tesla some time since established his right to be known as the most promising electrical inventor of to-day. When on March 13 last his laboratory, his workshop and all its contents, and most of his important records were totally destroyed by fire, the loss was felt by every one familiar with recent electrical developments.

Tesla, although an extremely modest man, is very widely known through his achievements in pure currents. His first public lecture was based on these discoveries.

Since Tesla's discovery of the "rotating magnetic field" the long-distance transmission of alternating current from Niagara Falls has become possible. The basic idea of this discovery is to produce a circularly shifting magnetism instead of the well-known phenomenon of magnetism in a fixed position.

To the lay mind the most wonderful of all Tesla's experiments was the lighting of electric lamps or empty glass bulbs in free space, without any connection with the wires or generating apparatus. The light from these Tesla tubes is so intense that photographs taken by their illumination have been made with exposures of eight to 10 minutes.

again the labor of years in the hope of reconstructing what had been totally wiped out. He is now busily engaged at this herculean task.

In view of the fact that Mr. Tesla's most important records were burned, it is extremely fortunate that the persuasions of Mr. Thomas Commerford Martin resulted in securing photographs of a number of pieces of apparatus which Mr. Tesla had developed and constructed more than a year ago. The illustrations which accompany this article were made from the photographs referred to. The half-tone plates were engraved at the time the photographs were taken, another fortunate circumstance, as the original prints were burned with everything else the Tesla laboratory contained.

Naturally, Mr. Tesla does not wish to have complete technical evidence

Fig. 1.—The Tesla Oscillator Shown at Chicago in 1893.

Fig. 2.—A Similar Form of Oscillator.

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FIG. 1.—THE TESLA OSCILLATOR SHOWN AT CHICAGO IN 1893.

FIG. 2.—A SIMILAR FORM OF OSCILLATOR.

electrical science and through the many articles that have been written about him and his work by lay and technical writers. The loss which he recently sustained was a most serious one and called forth expressions of sympathy from every side. It resulted in his receiving one of the highest compliments ever paid to any man. This was from the pen of Charles A. Dana, editor of the New York *Sun*, and a warm admirer of Tesla. Mr. Dana wrote as follows:

> The destruction of Nikola Tesla's workshop, with its wonderful contents, is something more than a private calamity. It is a misfortune to the whole world. It is not in any degree an exaggeration to say that the men living at this time who are more important to the human race than this young gentleman can be counted on the fingers of one hand; perhaps on the thumb of one hand.

Immediately following the fire Mr. Tesla, instead of being prostrated by his misfortune, as reported in several daily newspapers, secured new quarters in which he began all over

Naturally, Mr. Tesla does not wish to have complete technical evidence of his work published abroad while he is in his present crippled condition, yet it is by his permission that these particulars are given here.

In the course of lectures, all too few in number, Mr. Tesla has at different times demonstrated before technical societies in this country and abroad a number of experiments wonderful in themselves and yet puny in comparison with the deep work of which they were but a feeble outgrowth. It has come to be pretty generally understood that the principal objects of Mr. Tesla's labors were the more efficient production of light, heat and power by electricity and the transmission of energy over long distances. His name is especially associated with the discovery of new phenomena resulting from his researches into the qualities and effects of high potential and high frequency

The wide field for improvement open to Mr. Tesla in his efforts to discover more efficient means of generating electrical energy may be better appreciated when it is stated that actual tests have shown that the energy manifesting itself as light in an incandescent lamp is less than five per cent of that received as current. The other 95 per cent is lost between the coal pile and the lamp. An important step in Mr. Tesla's labors to reduce this tremendous loss was the invention of his "oscillator." He reasoned that if large losses occurred in the steam engine and other large losses in the dynamo, it would minimize the combined losses if both machines were blended in one. And in the crudest terms this is what an oscillator is—an engine-dynamo.

In generating current by a revolving armature there is always some part of the wire winding which is doing no work, just as in the steam engine the steam cylinder and its

April 2, 1895

piston are the only parts doing any work, all the other complex mechanism being used for control or regulation. In brief and popular terms, the Tesla oscillator consists of a bed-plate, in the middle of which is located a steam chest. On each side of the steam chest is an electro-magnetic system consisting of field coils, between which the armatures move.

Two pistons are worked by the steam entering the chest. In one case steam at 350 pounds pressure is used, although as low as 80 pounds is used in other oscillators. At the ends of the pistons are the armature coils, which are thrust in and out of the magnetic fields with a reciprocating motion, thus generating current.

Here, then, is a steam engine stripped of every inefficient complication, and at the same time it is an electrical generator in which every part is doing steady work. The [illegible]

FIG. 3.—ANOTHER TYPE OF TESLA OSCILLATOR.

oscillator, and one that was entirely practical and successful, had been used for many months in Tesla's laboratory. It was used to light the rooms with incandescent lamps and also furnished current for four arc lamps, for motors, for experiments with the high frequency apparatus and for other investigations. Many visitors to the laboratory have witnessed this oscillator in successful operation.

The oscillator which Mr. Tesla used in his lecture before the International Electrical Congress, during the World's Fair at Chicago, in August, 1893, is the only one that has ever been exhibited in public. This is shown in the accompanying illustration, Fig. 1. For convenience, compressed air instead of steam was used to operate this oscillator during Mr. Tesla's lecture. The machine consists of an engine mounted on an [illegible] [illegible] generator [illegible]

at a constant temperature by any usual means. The isochronism is perfect because the frictional losses are infinitesimally small compared with the enormous elastic force.

Another quite distinct type is illustrated in Fig. 3. On a stand with a dynamo of somewhat unusual form is mounted a small oscillator. The dynamo includes a circular field magnet in which circular coils are arranged to move on each side. An arbor directly connected to the small engine carries the coils, and currents are produced by vibrating the coils within the field of the magnet. Mr. Tesla says that in this form there is absolutely no useless wire. All of it is within the field and all is equally active.

An oscillator of more advanced form, operated by steam and freely used for laboratory purposes, is shown in Fig. 4. This extremely small machine had a capacity of 12 incandescent lights. This combination was [illegible]

used by Mr. Tesla in his demonstrations is illustrated in Fig. 6. Novel features were exemplified by the use of several of the instruments shown. As an example, the magnets in A served to make clear the principle of the preponderance of one impulse over the other in the current produced by the oscillator and creating virtually the effect of a direct or continuous current. A magnet which was vibrated is shown in B. The copper disk D was arranged to rotate freely in bearings. When the disk was held between the poles, that is, in the field of the vibrating ring magnet, it was rotated in one direction. This showed that the currents distributed in the disk were asymmetrical, or in other words, they were preponderating in one direction.

The constancy or invariability of the speed of the oscillator was illustrated by the use of the little motor shown at C in Fig. 6. Another little motor with clockwork attached, shown in G, was used to count the revolutions of the oscillator. Both of these little motors were driven from arc circuit, the difference of phase being obtained by artificial means. E was a little generator com-

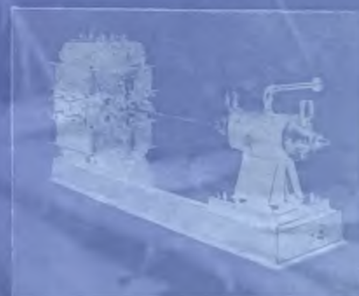

FIG. 4.—OSCILLATOR USED FOR LABORATORY PURPOSES.

Electrical Review (N.Y.) June 5, 1895

are to be men who will especially look after the development of the company along its present lines of policy. B.

Monday, June 3, 1895.

The Burning of Tesla's Laboratory.

Now that a little time has elapsed since the disaster which overwhelmed Nikola Tesla's laboratory, it is possible to sum up the significance of the event. Our sympathies have been with this unfortunate physicist from the first, and for good reasons. But the average newspaper man, who, by the way, was mostly extravagant with his commisseration, would probably hesitate to venture upon an answer were he asked to explain definitely what he was grieving about. The thing was terribly overdone at the time it happened, and, in illustration of this, we believe it to be a fact that one vivid young lady of the transatlantic press, in her anxiety to be instructive as well as "alive" in her descriptions, went so far as to depict herself undergoing a brilliant electrical ordeal, that is possible only with the body *in puris naturalibus!* For Tesla's future we have no fear. He is young and indomitable. It took Thomas Carlyle four weeks to quiet his mind after that miserable accident in which John Stuart Mill was concerned, which entailed the destruction of the first volume of the unprinted "French Revolution." But, in spite of sensational reports, we know it to be a fact that Tesla was at work again with clenched determination while the ashes of his hopes are still hot. No! The loss falls least heavily upon the loser. Like many another tireless experimenter, he hoped to give the scientific world the report of his failures as well as of his discoveries; he had not counted upon the casual distruction of his memorabilia and apparatus by fire. The loss falls most heavily upon those scientists who are at work upon the phenomena of high-frequency currents, of insulation, induction, impedance, and resonance, and the problems of obtaining cheap electricity by means of oscillators. In time, Tesla will doubtless reproduce all that was of value in those unfortunate

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notes and papers. In his own immediate work their loss will scarcely be felt, for his memory is all right, and flashes upon any experience of the past with the revealing power of a search-light. But the years of toil which his work might have saved experimenters by indicating the paths which are open as well as those which are blind, are gone forever.—*London Electrical Review.*

The way the New York Edison Illuminating bonds were snapped up

Jan 25, 1899

but to a residence in the same block and on the same side of the street. The goods were held one week by the express company and then delivered to the right number in a condition which could give aromatic points to the embalmed beef discovered by General Miles in Cuba and Porto Rico. We should think a company of the caliber of the Adams Express would have men in charge of its city offices intelligent enough to look at one of several city or telephone directories or make some sensible effort to deliver goods promptly.

The general public in and around New York city is just as much as ever, if not more, interested in electrical progress. Bearing this in mind, it seems to us that the National Electric Light Association, as a prominent and influential organization with which the people are familiar, and the Electrical Exhibition Company, which proposes to hold an electrical exposition in the Madison Square Garden next Spring, should combine their forces and influence to produce the very best possible setting forth of all that is latest and best in electrical development. It is to be hoped that electrical manufacturers will do all in their power to make the forthcoming exhibition a representative and instructive one.

Mr. Russel Sage was quoted last week as denying the published report saying that President Gould and Vice-President Gallaway are opposing the substitution of electricity for steam-power on the Manhattan Railway of New York city while he was advocating the change. Mr. Sage denied that there was any friction, and stated that all the gentlemen named were working in harmony. Mr. Sage also intimated that he was

THE END OF KEELY.

Beginning probably with the celebrated "Mississippi scheme" of John Law about 1718, the world has, in the last two centuries, submitted to some gigantic frauds and the people have put their money on the more or less masterly shell-games by millions. The bubbles have burst, and generally within a comparatively short space of time. But it remained for Keely to break the great record, for he fooled his dupes for almost a quarter of a century, and longer, for some of them really appear yet to believe in his motor.

It is a wonderful record, all the more so that the fraud was perpetrated on and really believed in by many men of superior intelligence, and by some who had more or less scientific and mechanical training. In the old palmy days of Keely, many a man of cautious and mature judgment, on witnessing the so-called manifestations of the "etheric force" of the great charlatan, would shake his head in perplexity and admit he was at a loss to controvert the apparent facts. And often such a man would ponder over the possibilities of such a new engine and wind up his cogitations by drawing his check and buying Keely stock. The fraud was too attractive for him and for many others.

Keely had a motor, however, and it was for years in successful operation; the world saw it, applauded, came forward and became itself the medium of the successful operation. The records show this. But this successful motor was only adapted for one kind of work, which was the transferring of hard-earned dollars from the pockets of the dupes to that of Keely. In that respect there was a very real Keely motor, but its dear public and unfailingly put them all snugly into the pockets belonging to the master-hand at the throttle. All the suavity and shrewdness and experience of all the bunco steerers in the country rolled into one could not approach such a success as this extraordinary individual conceived and executed in the teeth of all the experts of the world. Surely, history has no parallel to this. But Keely is dead, his laboratory has been dismantled, and his secret and fraud unearthed. It looks now as if the committee had done its work thoroughly and laid the ghost forever.

The Autotruck Company of New York city, is apparently doing a lively business in the selling of its shares, but who has seen an actual truck anywhere about the city loaded with "ten tons" of merchandise? Who ever will see a truck full of goods to the extent of ten tons tearing along our streets at a rate of ten miles per hour? What street would stand it? But while streets could not stand under such burdens, the public will stand anything in the way of promises. It is a life of hope we live, truly.

The Northwestern Electrical Association held a very successful annual convention at Milwaukee last week. The papers read before the delegates were interesting, and the discussions following were profitable. During the meeting the announcement was made that the Northwestern Electrical Association has a larger membership than any other similar organization in the United States. In view of the fact that the association represents the comparatively smaller central stations within its jurisdiction, this is an encouraging sign of the times. The "big fellows" are rather expected to look out

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[illegible]OTES.

[illegible] of the Boston
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[illegible]ating expenses,
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[illegible]

[illegible] will be grieved [illegible] on the authority of Mrs. Bl[illegible] [illegible] in the [illegible] that Mr. Tesla is in a [illegible] position. It is a number [illegible] says this gifted woman, since [illegible] crossed the border line of the [illegible] which other electricians [illegible] but he still remains in the interat[illegible] field of research, unmindful of the triple conditions that govern elec[illegible]ity in the relation which it sustains to the first order of [illegible]. This is sad enough, but we have [illegible] to tell the worst. It appears that by [illegible] Keely's system of resonan[illegible] missed the chance of hobnobbing with electrical phenomena [illegible] sympathetic field, and is standing on a bridge which connects the primary two-thirds of the electric stream—the subdominant current with the dominant. What a fearsome posi[illegible] his! But the consequences of his folly will still pursue him, and even though he may hook on to the dominant, he will still be subserved to the terrestrial neutral far in the rear of sympathetic [illegible] to radiating celestial outreach, the connecting link of which exists in the interluminous. Mrs. Moore says, further, that even in the event of Tesla's salvation, he will not have reached the compound interetheric. If such be the case, we should advise Mr. Tesla [illegible] down at once from his supradominant hypoluminous outreachment [illegible] longer seek to attain the [illegible] realm, but to content him[illegible] hard pan. The sting of Mrs. Moore [illegible] is, however, in her—well, [illegible] will understand [illegible] cash settlement, and Keely [illegible] down all his secrets, and [illegible] may make a 10,000 [illegible] gossamer in the Su[illegible] [illegible] outreach[illegible] reaching [illegible]

The Tesla Multiphase System.

Mr. Lemuel Bannister, vice-president and general manager of the Westinghouse Electric and Manufacturing Company, of Pittsburgh, is sending the following letter to central stations throughout the country:

In view of the great prominence given to the multiphase motors covered by the patents of Mr. Nikola [illegible] we think it right to direct [illegible] attention to the fact that this [illegible]any claims the exclusive right to manufacture and sell all forms of motors operated by currents of two, three or more phases, and all forms of single-phase motors where a second phase is induced so as to make the same a two-phase induction motor, notably the form used for the operation of fans. Suits are now pending against the Thomson Houston Electric Company (the General Electric Company), the Stanley Manufacturing Company, of Pittsfield, Mass., and numerous suits have been entered against the users of apparatus purchased from the above companies; it being the intention of this company to enforce its exclusive right to manufacture and sell multiphase generators and motors, the two being used in combination as a system, and such system being covered by the patents [illegible] Tesla above referred to. [illegible] named suits, the General [illegible] Company [illegible] de[illegible] and the court [illegible] [illegible] plete its testimony, [illegible] may be had in the latter part of this year or the beginning of 1896. We are advised that the defence has been unable to produce a single working [illegible] that can in any way take from [illegible] the pioneer character of [illegible]ntions.

We have been informed that the two companies named have offered [illegible]rantee the purchaser [illegible] ing apparatus against damage or loss, [illegible] companies desiring to remodel or to increase their plants to make a full and careful investigation of the Tesla apparatus as installed in our works at East Pittsburgh, and you are invited to come or send a representative, to whom every facility will be given for careful inspection.

The Baltimore Electric Locomotive.

The first high-speed trial of the Baltimore & Ohio Railroad Compan[illegible] electric locomotive took place in [illegible] Belt Line tunnel at Baltimore [illegible] September 6. The trial de[illegible] speed of 61 miles an hou[illegible] heavy grade of the tunnel, and [illegible] engineers said it was equivalent to 75 miles an hour on a level track. Th[illegible] performance of th[illegible] locomotive was such that they would not hesitate to run it at that, or even a greater speed, if they had a sufficient stretch of track for the purpose. This locom[illegible]tive was not designed for fast time, and the result of its latest test [illegible] looked upon as an indication of what may be expected from an electric locomotive [illegible] designed for such a purpose. Since August 4 the locomotive has been hauling th[illegible] entire freight service of the Baltimore & Ohio through the tunnel, and it has bee[illegible] every h[illegible] speed maint[illegible] freights ha[illegible]

The British A[illegible]

The sixty-fifth annual [illegible] of the British Associatio[illegible] vancement of Scienc[illegible] September 11 at Ipswich, [illegible] Lord Kelvin introduced the new president, Sir Douglas Galton, who [illegible] to read a long address

may be had in the latter part of this year or the beginning of 1896. We are advised that the defense has been [illegible]ble to produce a single working [illegible] that can in any way take from [illegible] the pioneer character of [illegible] inventions.

We have been informed that the two companies named have offered to guarantee the purchaser of infringing apparatus against damage or [illegible], but you can well appreciate that it will be impossible for such companies to make good their guarantees to cover *all* losses if the courts enjoin the use of apparatus made in imitation of that covered by Tesla's patents.

We are prepared to furnish multiphase generators and motors for all classes of work, and being the owners [illegible] arise by which the purchasers of such apparatus [illegible] be interfered with in its continued commercial use.

It is the opinion of those who have given the subject most careful attention, that [illegible] large proportion of the electric work [illegible] together with [illegible] that in the main, we believe, men would prefer to purchase property from its rightful owners, has led us to write to you and give you an opportunity to place your orders [illegible] multiph[illegible] to use, and thus avoid the risks incident to the purchase of apparatus from unlawful manufacturers.

The adoption by the General Electric Company of the term "Monocyclic" in connection with their use of multiphase apparatus, does not free them from the charge of infringement, but on the contrary makes the case against them stronger, because of the sale of apparatus under misleading terms.

In conclusion we wish to call your attention to the fact that with our system incandescent lights, arc lamps and alternating motors can be operated from the same circuits, and that it will be of especial advantage to

freights has been 15 miles an hour

The British A[illegible]

The sixty-fifth annual [illegible] the British Association for the A[illegible] vancement of Science opened September 11 at Ipswich, Engla[illegible] Lord Kelvin introduced the [illegible] president, Sir Douglas Galton, [illegible] started in to read a long addre[illegible] After reading three-quarter[illegible] address Sir D[illegible] soon recovered, [illegible] read the rest of the addre[illegible] those present were [illegible] Remsen of Johns Hopkins Univer[illegible] Baltimore, and Dr. Frederick Bo[illegible] of Cornell Universit[illegible]

Telegraphers are alarmingly su[illegible] ject to consumption, according to [illegible] *British Medical Journal.* Out [illegible] 100 deaths among all adult males [illegible] England, 13.8 are due to consumpti[illegible] out of 100 deaths among the grind[illegible] in the cutlery trade who are specia[illegible] subject to the disease, 33.1 are [illegible] to it, while the proportion for [illegible] telegraph operators is 46.6 in 1[illegible] More than half of them di[illegible] diseases of the respiratory orga[illegible] against 24 per cent only in all ot[illegible] occupations.

H. C. Bunner, the editor of *Pu*[illegible] has written for the October *Scrib*[illegible] an account of the rise and develo[illegible] ment of the poster habit in Americ[illegible] with a very amusing series of illu[illegible] trations.

[illegible] co[illegible]
almost caught up
[illegible] ever before
We have al[illegible]
[illegible] wit[illegible]

[illegible]

[illegible] of the wall, where the [illegible] stream strikes, should appear as if the glass were in a fluid state.

As a cooling medium I have found best to employ jets of cold air. By this means it is possible to operate successfully a bulb with a very thin wall, while the passage of the rays is not materially impeded.

I may state here that the experimenter need not be deterred from using a glass bulb, as I believe the opacity of glass as well as the transparency of [illegible] are somewhat exaggerated, inasmuch as I have found that a very thin aluminum sheet throws a marked shadow, while, on the other hand, I have obtained impressions through a thick glass [illegible].

The above method is valuable not only as a means of obtaining the high vacua desired, but it is still more important, because the phenomena observed throw a light on the results obtained by Lenard and Roentgen.

Though the phenomenon of rarefaction under above conditions admits of different interpretations, the chief interest centers on one of them, to which I adhere—that is, on the actual expulsion of the particles through the walls of the bulb. I have lately observed that the latter commences to act properly upon the sensitive plate only from the point when the exhaustion begins to be noticeable, and the effects produced are the strongest when the process of exhaustion is most rapid, even though the phosphorescence might not appear particularly bright. Evidently, then, the two effects are closely connected, and I am getting more and more convinced that we have to deal with a stream of material particles, which strike the sensitive plate with great velocity. Taking as a basis the estimate of Lord Kelvin on the speed of projected particles in a Crookes bulb, we arrive easily by the employment of very high potentials to speeds of as much as a hundred kilometres a second. Now, again, the old question arises: Are the particles from the electrode or from the charged surface generally, including the case of an external electrode, [illegible] actual projection, [illegible] streamers being absolutely prevented by careful static screening.

A peculiar thing about the Roentgen rays is that from low frequency to the highest obtainable there seems to be no difference in the quality of the [illegible], [illegible] that they are more intense when the frequency is higher, which is very likely due to the fact that in such case the maximum pressures on the cathode are likewise higher. This is only possible [illegible] that the effects on the sensitive plate are due to projected particles, or else to vibrations far beyond any frequency which we are able to obtain by means of condenser discharges. A powerfully excited bulb is enveloped in a cloud of violet light, extending for more than a foot around it, but outside of this visible phenomenon there is no positive evidence of the existence of waves similar to those of light. On the other hand, the fact that the [illegible] bears some proportion to the density of the substance speaks strongly for material streams, and the same may be said of the effect discovered by Prof. J. J. Thomson. It is to be hoped that all doubts will shortly be dispelled.

A valuable evidence of the nature of the radiations and progress in the direction of obtaining strong impressions on the plate might be arrived at by perfecting plates especially sensitive to mechanical shock or impact. There are chemicals suitable for this, and the development in this direction may lead to the abandonment of the present plate. Furthermore, if we have to deal with streams of material particles, it seems not impossible to project upon the plate a suitable substance to insure the best chemical action.

With apparatus as I have described, remarkable impressions on the plate are produced. An idea of the intensity of the effects may be gained when I mention that it is easy to obtain shadows with comparatively short exposures at distances of many feet, while at small distances and with thin objects, exposures of a few [illegible] clear outline of the abdomen [illegible] and the location of the lungs, the fur and many other features. [illegible] of even large birds show the feathers quite distinctly.

Clear shadows of the bones of human limbs are obtained by exposures ranging from a quarter of an hour to an hour, and some plates have shown such an amount of detail that it is almost impossible to believe that we have to deal with shadows only. For instance, a picture of a foot with a shoe on it was taken, and every fold of the leather, trousers, stocking, etc., is visible, while the flesh and bones stand out sharply. Through the body of the experimenter the shadows of small buttons and like objects are quickly obtained while with an exposure of from one to one and a half hour the ribs, shoulder bones and the bones of the upper arm appear clearly, as is shown in the annexed print. It is now demonstrated beyond any doubt that small metallic objects or bony or chalky deposits can be infallibly detected in any part of the body.

The outline of the skull is easily obtained with an exposure of 20 to 40 minutes. In one instance an exposure of 40 minutes gave clearly not only the outline, but the cavity of the eye, the chin and cheek and nasal bones, the lower jaw and connections to the upper one, the vertebral column and connections to the skull, the flesh and even the hair. By exposing the head to a powerful [illegible] strange effects have been noted. [illegible] instance, I find that there is a tendency to sleep and the time seems to pass away quickly. There is a general soothing effect, and I have felt a sensation of warmth in the upper part of the head. An assistant independently confirmed the tendency to sleep and a quick lapse of time. Should these remarkable effects be verified by men with keener sense of observation, I shall still more firmly believe in the existence of material streams penetrating the skull. Thus it may be possible by these strange appliances to project a suitable chemical into any part of the body.

Roentgen advanced [illegible] results [illegible] warning against too much hope. Fortunately his apprehensions were groundless, for, although we have to all appearances to deal with mere shadow projections, the possibilities of the application of [illegible] discovery are vast. I am [illegible] have contributed to the development of the great art he has created.

NIKOLA T[illegible]

New York, March [illegible], 1896.

bulb has then reached the required degree of rarefaction. The process may be hastened by repeated heating and cooling and by the employment of a small electrode. It should be added that bulbs with external electrodes may be treated in the same way. It may be also of interest to state that under certain conditions, which I am investigating more closely, the pressure of the gas in a vessel may be augmented by electrical means.

I believe that the disintegration of the electrode, which invariably takes place, is connected with a notable diminution of the temperature. From the point on, when the electrode gets cool, the bulb is in a very good condition for producing the Roentgen shadows. Whenever the electrode is equally, if not hotter than the glass, it is a sure indication that the vacuum is not high enough, or else that the electrode is too small. For very effective working, the inside surface of the wall, where the cathode stream strikes, should appear as if the glass were in a fluid state.

As a cooling medium I have found it best to employ jets of cold air. By these means it is possible to operate successfully a bulb with a very thin wall, while the passage of the rays is not materially impeded.

I may state here that the experimenter need not be deterred from using a glass bulb, as I believe the opacity of glass as well as the transparency of aluminum are somewhat exaggerated, inasmuch as I have found that a very thin aluminum sheet throws a marked shadow, while, on the other hand, I have obtained impressions through a thick glass plate.

The above method is valuable not only as a means of obtaining the high vacuum desired, but it is still more important because the phenomena observed throw a light on the results obtained by Lenard and Roentgen.

Although the phenomenon of [illegible] action under above [illegible] expulsion of the particles through [illegible] or do they merely hit the inner surface and cause particles from the outside of the wall to fly off, acting in a purely mechanical way, as when a row of ivory balls is struck? So far, most of the phenomena indicate that they are projected through the wall of the bulb, of whatever material it may be, and I am seeking for still more conclusive evidence in this direction.

It may not be known that even an ordinary streamer, breaking out suddenly and under great pressure from the terminal of a disruptive coil, passes through a thick glass plate as though the latter were not present. Unquestionably, with such coils pressures are practicable which will project the particles in straight lines even under atmospheric pressure. I have obtained distinct impressions in free air, not by streamers, as some experimenters have done, using static machines or induction coils, but by actual projection, the formation of streamers being absolutely prevented by careful static screening.

A peculiar thing about the Roentgen rays is that from low frequency to the highest obtainable there seems to be no difference in the quality of the effects produced, except that they are more intense when the frequency is higher, which is very likely due to the fact that in such case the maximum pressures on the cathode are likewise higher. This is only possible on the assumption that the effects on the sensitive plate are due to projected particles, or else to vibrations far beyond any frequency which we are able to obtain by means of condenser discharges. A powerfully excited bulb is enveloped in a cloud of violet light, extending for more than a foot around it, but outside of this visible phenomenon there is no positive [illegible] of the existence of [illegible] similar to those of light. On [illegible] hand, the fact that the [illegible] some proportion to the [illegible] substance [illegible] discovered by Prof. J. J. Thomson [illegible]

seconds are practicable. The annexed print is a shadow of a copper wire projected at a distance of 11 feet through a wooden cover over the sensitive plate. This was the first shadow taken with my improved apparatus in my laboratory. A similar impression was obtained through the body of the experimenter, a plate of glass, nearly three-sixteenths of an inch thick, a thickness of wood of fully two inches and through a distance of about four feet. I may remark, however, that when these impressions were taken, my apparatus was working under extremely unfavorable conditions, which admitted of so great improvements that I am hopeful to magnify the effects many times.

The bony structure of birds, rabbits and the like is shown within the least detail, and even the hollow of the bones is clearly visible. [illegible] plate of a rabbit under exposure of an hour, not only every detail of the skeleton is visible, but likewise a clear outline of the abdominal cavity and the location of the [illegible] fur and many other features. [illegible] of even large birds show the feathers quite distinctly.

Clear shadows of the bones of human limbs are obtained by exposures ranging from a quarter of an hour to an hour, and some plates have shown such an amount of detail that it is almost impossible to believe that we have to deal with shadows only. For instance, a picture of a foot with a shoe on it was taken, and every fold of the leather, trousers, stocking, etc., is visible, while the flesh and bones stand out sharply. Through the body of the experimenter the shadows of small buttons and like objects are quickly obtained, while with an exposure of from one [illegible] and a half hours the [illegible] shoulder [illegible] bones [illegible] appear clearly [illegible] as shown [illegible] the annexed print. It is now demonstrated beyond any doubt that small metallic [illegible] deposits [illegible] any part of the body.

An outline [illegible] obtained [illegible] to the upper one, the vertebral column [illegible]

...N ROENTGEN RAYS

...consequence ... popular ... in regard to the con...

...bulb, on which I have ... particulars on previous ...

Having selected the induction ... type of bulb, ...

...Roentgen shadows ... method of rarefaction by electrical means to any degree desirable, far ... and that obtainable by mechanical ...

...of an ... coil giving ... sufficient potential, I have found that by far the most suitable apparatus, and one which secures the quickest action, is a disruptive coil. It is best to proceed in this way: The bulb is first exhausted by means of an ordinary vacuum pump to a high degree, though my experiences have shown ...

An interesting and important decision has just been rendered by Judge Townsend, of the United States Circuit Court for the district of Connecticut, upon the Van Depoele patent No. 495,443, for the underrunning electric railway trolley system. A few months ago Judge Townsend rendered a decision sustaining the validity of this patent on final hearing in a suit against the Winchester Avenue Railroad company. Shortly thereafter further infringement suits were brought in Connecticut against the Billings & Spencer company, of Hartford, and the Kelsey Electric Railway Specialty company, of New Haven. Judge Townsend has just decided these cases in favor of the Van Depoele patent, and granted motions for preliminary injunctions after full argument on both sides. The decision is especially important because the court holds that the supply of essential or characteristic parts of the trolley system is a contributory infringement, and will be enjoined by the courts, even though the defendant may not supply or use the patented combination or system in its entirety. The court further held that an unlicensed maker of trolley bases could not be permitted to supply such bases even to railroads which had been originally fully equipped by the General Electric Company, the present owner of Van Depoele patent No. 495,443.

found that by far the most suitable apparatus, and one which secures the quickest action, is a disruptive coil. It is best to proceed in this way: The bulb is first exhausted by means of an ordinary vacuum pump to a rather high degree, though my experiences have shown that this is not absolutely necessary, as I have also found it possible to rarefy, beginning from low pressure. After being taken down from the pump, the bulb is attached to the terminal of the disruptive coil, preferably of high frequency of vibration, and usually the following phenomena are noted: First, there is a milky light spreading through the bulb, or possibly for a moment the glass becomes phosphorescent, if the bulb has been exhausted to a high degree. At any rate, the phosphorescence generally subsides quickly and the white light settles around the electrode, whereupon a dark space forms at some distance from the latter. Shortly afterward the light assumes a reddish color and the terminal grows very hot. This heating, however, is observed only with powerful apparatus. It is well to watch the bulb carefully and regulate the potential at this stage, as the electrode might be quickly consumed.

After some time the reddish light subsides, the streams becoming again white, whereupon they get weaker and weaker, wavering around the electrode until they finally disappear. Meanwhile, the phosphorescence of the glass grows more and more intense, and the spot where the stream strikes the wall becomes very hot, while the phosphorescence around the electrode ceases and the latter cools down to such an extent that the glass near it may be actually ice-cold to the touch. The gas in the

...Radiograph of Right Shoulder of a Man, Showing Ribs and Shoulder and Upper Arm Bones—Taken ... at a Distance of Four Feet.

TESLA ON ROENTGEN RAYS.

A HIGHLY INTERESTING AND VALUABLE COMMUNICATION FROM THE TALENTED YOUNG INVENTOR.

To the Editor of Electrical Review:

One can not help looking at that little bulb of Crookes' with a feeling of awe, when he considers all ... it has done for ... by ... the brilliant work of Lenard, ... ments of Roentgen. Possibly it may still contain a grateful Asmodeus, ... be let out of his narrow ... student. At ... mes it has seemed ... heard ... I have searched ...

... is a brief statement which, I hope, will be useful, of the methods employed and of the most notable ... arrived at in these two directions ...

... Respects to Prof. Roentgen—A Radiograph of a Wire ... sion Taken Through a Wooden Cover at the Remarkable Distance of Eleven Feet, with One-Half Horse ...

In order to produce the most intense effects we have first to consider ... may depend necessarily on the intensity of ... dependent on the magnitude of the potential. ... avail ourselves of an ordinary induction coil, or of a static machine, or of a disruptive discharge coil. I have the impression that most of the results in Europe have been arrived at ... of a static machine or Ruhmkorff ... But since these appliances can produce only a comparatively small potential, we are naturally thrown on the use of the disruptive discharge coil as the most effective apparatus. With this there is practically no limit to the spark length, and the ... perimenter should possess a certain knowledge and skill in the adjustments of the circuits, particularly ... out in my earlier writings on this subject.

After constructing a disruptive coil suitable for any kind of current supply, direct or alternating, the experimenter comes to the consideration as to what kind of bulb to employ. Clearly, if we put two electrodes in a bulb, or use one inside and another outside electrode, we limit the potential, for the presence not only of the anode but of any conducting object has the effect of reducing the practi... ... driven to the acceptance of a single electrode bulb, the other terminal being as far remote as possible. ... should be employed to get the highest velocity of the cathode streams, for ...

TESLA'S WORK IN RADIOGRAPHY.

Radiography leads all discoveries of modern times in the intelligent and spontaneous attention it has received from scientists and experimenters all over the civilized world. The announcement of Nikola Tesla's achievements in the new art, first published in the ELECTRICAL REVIEW of March 11, in the author's own modest language, has added fresh impetus to the work in this direction. His disruptive discharge coil has been universally used where the best results in radiography [illegible] obtained, and his two marked improvements, namely, the single electrode tube and his method of rarefaction, promise great results. Other important points about Tesla's work are the fine details he has obtained in his radiographs, the great distance at which the radiographs have been made, and brief time of exposure.

We feel sure that the second communication from Mr. Tesla, which we publish in this issue, will be appreciated by our readers. He now produces shadows at 40 feet [illegible] and promises still more. He, furthermore, brings out the important fact of reflection of the rays, demonstrating this property beyond any doubt, besides other interesting details bearing on the nature of the radiation. To most men the facts presented will appear as a revelation.

The pleasant criticism of our half-tone reproduction of the radiograph of the shoulder of a man is, we admit, justified, but any one who knows the difficulties of the procedure involved will be convinced that as much was done as could be done under the circumstances.

Mr. Tesla is pursuing quietly his

bulbs I frequently experience a sudden, and sometimes even painful shock in the eye. Such shocks may occur so often that the eye gets inflamed, and one can not be [illegible] sidered over-cautious if he [illegible] from watching the bulb too [illegible] I see in these shocks a further e[illegible] of larger particles being throw[illegible] from the bulb. NIKOLA T[illegible]

New York, March 1[illegible]

DEVELOPMENTS IN RADIOGRAPHY.

WHAT SCIENTISTS AND O[illegible] RECENTLY ACCOMPLISHED.

The New York *Sun* published a dispatch from its London Co[illegible] spondent, dated March 14, in which it is said that the German Emperor takes the keenest interest in Professor Roentgen's discovery. The statement is made that the Kaiser has had his left arm photographed by the new process. This arm, as every one knows, is quite useless, and the photograph revealed the nature of the malformation. The photograph has been submitted to eminent surgeons, who said that they believe a simple operation may give the [illegible]

The firs[illegible] Johns Ho[illegible] which [illegible]

[illegible]

York at the regular March meeting [illegible] the Brunswick, on the Roentgen [illegible] and what Princeton was doing [illegible] the development of them. [illegible]

ELEC. REV. (N.Y.) MAR.

TESLA'S LATEST RESULTS

[illegible] RADIOGRAPHS [illegible] OF MORE THAN [illegible] FEET.

[illegible] Review.

[illegible]

stand [illegible] shadow [illegible] repeat, [illegible] is this all [illegible] on the [illegible]

[illegible] deeply [illegible] still more so, as [illegible] the possibility, [illegible] certitude, of augmenting the effects with my apparatus [illegible] What may we then expect? We have to deal here, evidently, with a radiation of astonish-

[illegible] deeply astonished observing these unexpected manifestations, and still more so, as even now I see before me the possibility, not to say certitude, of augmenting the effects with my apparatus at least tenfold! What may we then expect? We have to deal here, evidently, with a radiation of astonish-

[illegible] that precautions must be made to guard the plates in my photographic department, located on the floor above, a distance of fully 60 feet, from being spoiled by long exposure to the stray rays. Though during my investigations I have performed many experiments which seemed extraordinary, I am deeply astonished observing these unexpected manifestations, and still more so, as even now I see before me the possibility, not to say certitude, of augmenting the effects with my apparatus at least tenfold! What may we then expect? We have to deal here, evidently, with a radiation of astonishing power, and the inquiry into its nature becomes more and more interesting and important. Here is an unlooked-for [illegible] of an action [illegible] wonderful in itself, [illegible] capable [illegible] explanation, and affords a good example of the fruitfulness of original [illegible]. These effects upon the sensitive plate at so great a distance I attribute to the employment of a bulb with a single terminal, which permits the use of practically any desired potential and the attainment of extraordinary speeds of the pro[illegible] such a bulb it [illegible] the action upon a [illegible] proportionately [illegible] when the usual kind of [illegible] I have already [illegible] feel sure that [illegible] developments are to be looked [illegible] direction. I consider [illegible], of enabling us [illegible] of a fluorescent [illegible] through an opaque substance, [illegible] beautiful one than the [illegible] upon the plate.

[illegible] previous communication [illegible] have made considerable [illegible] and can presently announce [illegible] result of importance. [illegible] obtained shadows by [illegible] thus demonstrat[illegible] the Roentgen [illegible] this property. One of [illegible] experiments may be cited here. [illegible] copper tube, about a foot [illegible] and one of its ends [illegible] by the plate-holder [illegible] sensitive plate, protected by a fiber cover as usual. Near the open end of the copper tube was placed a thick plate of glass at an angle of 45 degrees to the axis of the tube. [illegible] was then suspended above the glass plate at a distance of about eight inches, so that the bundle of rays fell upon the latter at an angle of 45 degrees, and the supposedly reflected rays [illegible] the [illegible] of the copper [illegible] exposure of 45 minutes [illegible] sharp shadow of a [illegible] object. [illegible] shadow was [illegible] by the [illegible] rays, as [illegible] action was [illegible] ex-[illegible] having been demonstrated [illegible] the [illegible] tests [illegible] stronger [illegible] im-[illegible] could be produced [illegible] the [illegible] through a thickness [illegible] copper equal to that of the tube. Concluding from the intensity of the action by comparison with an equivalent effect due to the direct rays, I find that approximately [illegible] per cent of the latter were reflected from the glass plate in this experiment. I hope to be able to report shortly and more fully on this and other subjects.

In my attempts to contribute my humble share to the knowledge of the Roentgen phenomena, I am finding more and more evidence in support of the theory of moving material particles. It is not my intention, however, to advance at present any view as to the bearing of such a fact upon the present theory of light, but merely seek to establish the fact of the existence of such material streams in so far as these isolated effects are concerned. I have already a great many indications of a bombardment occurring outside of the bulb, and I am arranging some crucial tests which, I hope, will be successful. The calculated velocities fully account for actions at distances of as much as 100 feet from the bulb, and that the projection through the glass takes place seems evident from the process of exhaustion, which I have described in my previous communication. An experiment which is illustrative in this respect, and which I intended to mention, is the following: If we attach a fairly exhausted bulb containing an electrode

[illegible] have already a great many indications of [illegible] occurring outside of the bulb, [illegible] am arranging some crucial tests which, I hope, will be successful. The calculated velocities fully account for actions at distances of as much as 100 feet from the bulb, and that the projection through the glass takes place seems evident from the process of exhaustion, which I have described in my previous communication. An experiment which [illegible] trative in this respect, and which I intended to mention, is the fol-

[illegible]

Usually such a streamer will break through the seal and crack the bulb, whereupon the vacuum is impaired; but, if the seal is placed above the terminal, or if some other provision is made to prevent the streamer from passing through the glass at that point, it often occurs that the stream breaks out through the side of the bulb, producing a fine hole. Now, the extraordinary thing is that, in spite of the connection to the outer atmosphere, the air can not rush into the bulb as long as the hole is very small. The glass at the place where the rupture has occurred may grow very hot—to such a degree as to soften; but it will not collapse, but rather bulge out, showing that a pressure from the inside greater than that of the atmosphere exists. On frequent occasions I have observed that the glass bulges out and the hole, through which the streamer rushes out, becomes so large as to be perfectly discernible to the eye. As the matter is expelled from the bulb the rarefaction increases and the streamer becomes less and less intense, whereupon the glass closes again, hermetically sealing the opening. The process of rarefaction, nevertheless, continues, streamers being still visible on the heated place until the highest degree of exhaustion is reached, whereupon they may disappear. Here, then, we have a positive evidence that matter is being expelled through the walls of the glass.

When working with high [illegible]

Co., electrical

Co., rubber

candescent lamps

ical supplies for

wire.........

carbon

arc lamps

two-phase

...ided when the ... the following ... n the phos... picture or ... building, ... abomina-

have never before possessed—namely, the ability to ... an abnormal or diseased condition of parts of the human body.

... CONTRIBUTION

We publish in this issue a communication from Mr. Tesla, which is even more inter...ing and ... than his previous contribu... sented in our ... announcing the extraord... obtained by means of his apparatus, which speak for the correctness of his conclusions regarding the character of the radiations, and after proving in crucial tests the long-sought-for property of reflection, he makes known a re... which will probably lead to one of the most importan... realizations in scien... His investigations of the reflective power of ... disclose a singular relation ... which seems capable of leading us to a deeper insig... the primary condition of matter ... we have ever ... heretofore. Why is zinc, for instanc... which is one of the first in Volta's electric contact series ... best reflectors ... such can only be ... rays emanating ... Let us hope th...

the correspond... The trunk lin... cent and other ... per cent, ... 23 ... line ...

In electr... little of ... General ...

The ... possession of ... that the new ...

TESLA ON REFLECTED ROENTGEN ...

have never before possessed—namely, the ability to see an abnormal or diseased condition of parts of the human body.

... SCIENCE.

We publish in this issue a communication from Mr. Tesla, which is even more interesting and important than his previous contributi... sented in our colum... announcing the extraordinary result obtained by means of his apparatus which speak for the correctness of his conclusions regarding the character of the radiations, and after proving in crucial tests the long-sought-for property of reflection, he makes known a result which will probably lead to one of the most important realizations in science. His investigation of the reflective power of ... ionship which seem ... leading us to a deeper insight into the primary condition of matter than we have ever been able to ... heretofore. Why is zinc, for instance, which is one of the first in the voltaic electric contact series, one of the ... such can only be the case if ... mysterious rays emanating from the bulb convey ... state or condition ... soon the full ... minate ... promising fields

... nodded when the ... ated the following: ... sees on the phos- ... shadow picture of ... his bones ... is an abomina- ... New York daily ... world the orig- ... in Edison's ... the reporter ... of the possibility

The trunk lines ... cent and other ... per cent, while the ...

In electrical ... little of more ... 36⅜ on Mon... This movement ... possession of a ... that the new agree... put into effect unt... delay ... number of deta... There is no doubt ... is being steadily bo... Its future, however, ... of value, depends ... capital impairment.

... with this contention ... I find that anoth... streams both affect the ... furthermore I have ...

In this manner it was possible to compare the amount of the ... the following order ... copper, silver ...

TESLA ON REFLECTED ROENTGEN RAYS.

(Concluded from page 171.)

This is easily done by reducing the number of impulses or their duration, when raising the potential. For such experiments, it will be found of advantage to use in connection with the ordinary induction coil a rotating commutator, instead of a vibrating brake. By changing the speed of the commutator, and also regulating the duration of contact, one is enabled to adjust the conditions to suit the degree of vacuum and potential employed.

In my experiments on reflection, presently considered, I have used the apparatus shown in Fig. 2. It consists of a T-shaped box throughout, of a square cross-section. The walls are made of lead over one-eighth of an inch thick, which, under the conditions of the experiments, was found to be entirely impervious, even by long exposures to the rays. On the top end was supported firmly the bulb b, inclosed in a glass tube t of thick Bohemian glass, which reached some distance into the lead box. The lower end of the box was tightly closed by a plate-holder P_1 containing the sensitive film p_1 protected as usual. Finally the side end was closed by a similar plate holder P, with the sensitive protected film p. To obtain sharp images the objects o and o_1, exactly alike, were placed in the center of the fiber cover, protecting the sensitive plates. In the central portion of the box, provision was made for inserting a plate r of material, the reflective power of which was to be tested, and the dimensions of the box were such that the reflected ray and the direct one had to go through the same distance, the reflecting plate being at an angle of 45 degrees to the incident as well as reflected ray. Care was taken to exclude all possibility of action upon the plate p, except by reflected rays, and the reflecting plate r was made to fit tight all around in the lead box, so that no rays could reach the film p_1, except by passing through the plate to be tested. In my earlier experiments on reflection I observed only the effects of reflected rays, but in this instance, on the suggestion of Prof. Wm. A. Anthony, I provided the above means for simultaneously examining the action of the direct rays, which eventually passed through the reflecting plate. In this manner it was possible to compare the amount of the transmitted [illegible] ... A summary of the observations is given in the following table:

Body.	Impression by transmitted rays.	Impression by reflected rays.
[illegible]	Strong.	Fairly strong.
[illegible]	Barely perceptible.	Very feeble.
Zinc.	None.	Very strong.
Aluminum.	Very strong.	None.
Copper.	None.	Fairly strong, but much less than glass.
Lead.	None.	Very strong, but a little weaker than zinc.
Silver.	Strong, a thin plate being used.	Weaker than [illegible]
Tin.	None.	[illegible]
Nickel.	None.	[illegible]
Lead-glass.	Very strong.	[illegible]
Mica.	Very strong.	[illegible]
Ebonite.	Strong.	About like copper.

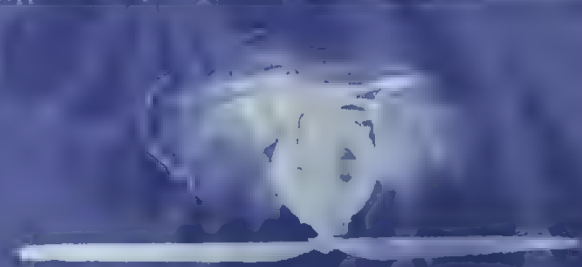
By comparing, as in previous experiments, the intensity of the impression by reflected rays with an equivalent impression due to a direct exposure of the same bulb and at the same distance—that is, by calculating from the times of exposure under assumption that the action upon the plate was proportionate to the time—the following approximate results were obtained:

	Impression by direct action.	Impression by reflected rays.
[illegible]	100	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	100	[illegible]
[illegible]	100	[illegible]
Copper	100	[illegible]
Lead	[illegible]	[illegible]
Silver	100	[illegible]
Tin	100	[illegible]
Nickel	[illegible]	[illegible]
Lead-glass	[illegible]	[illegible]
Mica	[illegible]	[illegible]
Ebonite	[illegible]	[illegible]

While these figures can be but rough approximations, there is, nevertheless, a fair probability that they are correct, in so far as the relative values of the impressions by reflected rays for the various bodies are concerned. Arranging the metals according to these values, and leaving for the moment the alloys or impure bodies out of question, we arrive at the following order: Zinc, lead, tin, copper, silver. The tin appears [illegible] ... first fully as well as lead, but [illegible]

[illegible] gated the subject and find that I can not agree with this contention. On the contrary, I find that anodic and cathodic streams both affect the plate, and, furthermore, I have been led to the conviction that the phosphorescence of the glass has nothing whatever to do with the [illegible] impressions. An obvious [illegible] that such impressions [illegible] with aluminum vessels when there is no phosphorescence, and, as regards the anodic or cathodic character, the simple fact that we can produce impressions by a luminous discharge excited by induction of a closed vessel when there is neither anode nor cathode, would seem to [illegible] effectually of the assumption [illegible] the streams are issuing solely from one of the electrodes. It may, perhaps, be useful to point out here [illegible] simple fact in relation to the induction coils, which may lead an experimenter into an error. When a vacuum tube is attached to the terminals of an induction coil, both of the terminals are acted upon alike as long as the tube is not very highly exhausted. At a high degree of exhaustion both the electrodes act practically [illegible] pendently [illegible] they be [illegible] bodies possessing considerable capacity, the consequence is that the coil is unbalanced. If the cathode, for instance, is very large, the [illegible] on the anode may rise considerably, and if the latter [illegible] smaller, as is frequently the case, the electric density may be many times that on the cathode. It results from this [illegible] while the [illegible] the opposite [illegible] are made [illegible] ing the above [illegible] hotter anode [illegible] um than the [illegible] part [illegible]

From the previous tests on [illegible]



The Lundell "White Wings"

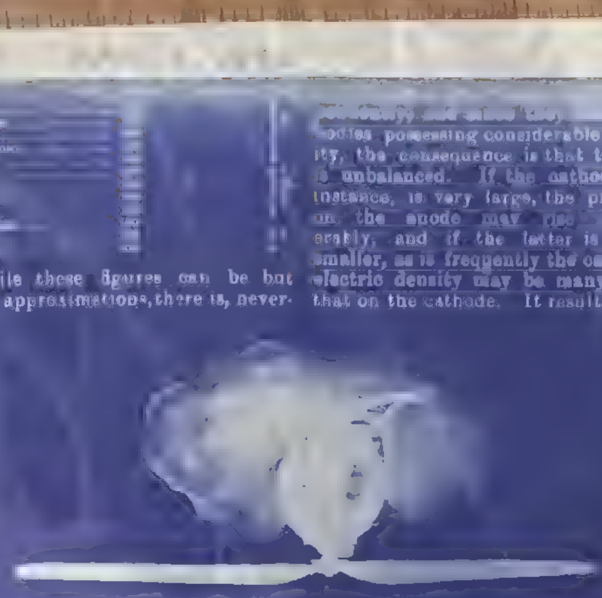
closed by a plate-holder P_1, containing the sensitive film p_1, protected as usual. Finally the side end was closed by a similar plate-holder P, with the sensitive protected film p. To obtain sharp images the objects o and o_1, exactly alike, were placed in the center of the fiber cover, protecting the sensitive plates. In the central portion of the box, provision was made for inserting a plate r of material, the reflective power of which was to be tested, and the dimensions of the box were such that the reflected ray and the direct one had to go through the same distance, the reflecting plate being at an angle of 45 degrees to the incident as well as reflected ray. Care was taken to exclude all possibility of action upon the plate p, except by reflected rays, and the reflecting plate r was made to fit tight all around in the lead box, so that no rays could reach the film p_1, except by passing through the plate to be tested. In my earliest experiments on reflection I observed only the effects of reflected rays, but in this instance, on the suggestion of Prof. Wm. A. Anthony, I provided the above means for simultaneously examining the action of the direct rays, which eventually passed through the reflecting plate. In this manner it was possible to compare the amount of the transmitted and reflected radiation. The glass tube t surrounding the bulb b served to render the stream parallel and more intense. By taking impressions at various distances I found that through a considerable distance there was but little spreading of the bundle of rays or stream of particles.

To reduce the error which is caused unavoidably by too long exposures and very small distances, I reduced the exposure to an hour, and the total distance through which the rays had to pass before reaching the sensitive plates was 20 inches, the distance from the bottom of the bulb to the reflecting plate being 13 inches.

It is needless to remark that all the precautions in regard to the sensitive plates—constancy of potential, uniform working of the bulbs, and maintenance of the same conditions in general during these tests have been taken, as far as it was practicable. The plates to be tested were made of uniform size, so as to fit the space provided in the lead box. Of the conductors the following were tested: Brass, toolsteel, zinc, aluminum, copper, lead, silver, tin, and nickel, and of the insulators, lead-glass, ebonite, and mica. The sum-

[illegible]	[illegible]
Aluminum	[illegible]
[illegible]	[illegible]
Ebonite	[illegible]

While these figures can be but rough approximations, there is, nevertheless, a fair probability that they are correct, in so far as the relative values of the impressions by reflected rays for the various bodies are concerned. Arranging the metals according to these values, and leaving for the moment the alloys or impure bodies out of question, we arrive at the following order: Zinc, lead, tin, copper, silver. The tin appears to reflect fully as well as lead, but, allowing for an error in the observation, we may assume that it reflects less, and in this case we find that this order is precisely the contact series of metals in air. If this proves true we shall be confronted with the most extraordinary fact. Why is zinc, for instance, the best reflector among the metals tested and why, at the same time, is it one of the foremost in the contact series? I have not as yet tried magnesium. The truth is that I was somewhat excited over these results. Magnesium should be even a better reflector than zinc, and sodium still better than magnesium. How can this singular relationship be explained? The only possible explanation seems to me at present that the bulb throws out streams of matter in some primary condition, and that the reflection of these streams is dependent upon some fundamental electrical property of the metals. This would seem to lead to the inference that these streams must be of uniform electrification; that is, that they must be anodic or cathodic in character, but not both. Since the announcement, I believe in France for the first time, that the streams are anodic, I have investi-



THE LUNDELL "WHITE [illegible]

[illegible] bodies possessing considerable capacity, the consequence is that the coil is unbalanced. If the cathode, for instance, is very large, the pressure on the anode may rise considerably, and if the latter is made smaller, as is frequently the case, the electric density may be many times that on the cathode. It results from this that the [illegible] while the cathode may be cool. [illegible] the opposite occurs if both of them are made exactly alike. But assuming the above conditions to exist, the hotter anode emits a more intense stream than the cool cathode, since the velocity of the particles is dependent on the electrical density, and likewise on the temperature.

From the previous tests [illegible] eating observation can also be [illegible] in regard to the opacity. For instance, a brass plate one-sixteenth inch thick proved fairly transparent, while plates of zinc and copper of the same thickness showed themselves to be [illegible] opaque.

Since I have investigated reflection and arrived to results in this [illegible] I have been able to produce [illegible] effects by employing proper reflectors. By surrounding a bulb with a very thick glass tube the effect may be augmented very considerably. The employment of a zinc reflector in one instance showed an increase of about [illegible] per cent in the impression produced. I attach great practical value to the employment of proper reflectors, because by means of them we can employ any quantity of bulbs and produce any [illegible] required.

One [illegible] of these investigations [illegible] entire failure of my [illegible] demonstrate refraction. I have [illegible] lenses of all kinds and tried a great many experiments, but [illegible] obtain [illegible]

New [illegible]

[illegible] (N.Y.) APR. 1 [illegible]

equal a century of progress. A [illegible] to live in such age, but a discoverer I would not wish to be.

Amongst the facts, which I have had the honor to bring to notice, one claiming a large share of scientific interest, as well as of practical importance, I refer to the demonstration of the property of reflection, on which I have dwelt briefly.

Having had opportunities to make many observations during my experience with vacuum bulbs and tubes, which could not be accounted for in any plausible way on any theory of vibration as far as I could judge, I began these investigations—disinclined, but expectant to find that the effects produced are due to a stream of material particles. I had many evidences of the existence of such streams. One of these I mentioned, describing the method of electrically exhausting a tube. Such exhaustion, I have found, takes place much quicker when the glass is very thin than when the walls are thick, I presume because of the easier passage of the ions. While a few minutes are sufficient when the glass is very thin, it often takes half an hour or more if the glass be thick or the electrode very large. In accordance with this idea I have, with a view of obtaining the most efficient action, selected the apparatus, and have found at each step my supposition confirmed and my conviction strengthened.

A stream of material particles, possessing a great velocity, must needs be reflected, and I was therefore quite prepared—assuming my original idea to be true—to demonstrate sooner or later this property. Considering that the reflection should be the more complete the smaller the angle of incidence, I adopted from the outset of my investigations a tube or bulb b of the form shown in Fig. [illegible]. It was [illegible] glass, with a bot-

[illegible] AND [illegible] EXPERIMENTS [illegible] TESLA'S [illegible] ROENT- [illegible] GEN RAYS.

the radiation sideways was restricted by the use of a very thick glass and most of it was thrown to the bottom by reflection, as I then surmised, it became evident that such a tube should prove much more efficient than one of ordinary form. Indeed, I quickly found that its power upon the sensitive plate was very nearly four times as great as that of a spherical bulb with an equivalent area of impact. This kind of tube is also very well adapted for use with two terminals by placing an external electrode e, as indicated by the dotted lines in Fig. [illegible]. When the glass is taken thick the stream is sensibly parallel and concentrated. Furthermore, by making the tube as long as one desired, it was possible to employ very high potentials, otherwise impracticable with short bulbs.

The use of high potentials is of great importance, as it allows shortening considerably the time of exposure, and affecting the plate at much greater distances. I am endeavoring to determine more exactly the relation of the potential to the effect produced upon the sensitive plate. I deem it necessary to remark that the electrode should be of aluminum, that when the Crookes [illegible] show themselves most prominently there is a reddish streamer issuing from the electrode, which in the beginning covers the latter almost entirely. Up to this point the bulb practically does not affect the sensitive plate, although the glass is very hot at the point of impact. Gradually the reddish streamer disappears, and just before it ceases to be visible the bulb begins to show better action, but still the effect upon the plate is very weak. Presently a white or even bluish stream is observed, and after some time the glass on the bottom of the bulb gets a glossy appearance. The heat is still more intense and the phosphorescence through the entire bulb is extremely brilliant. One should think that such a bulb must be effective, but appearances are often deceitful, and the beautiful bulb still does not work. Even when the white or bluish stream ceases, and the glass on the bottom is so hot as to be nearly melting, the effect on the plate is very weak. But at this stage there appears suddenly at the bottom of the tube a star-shaped changing design, as if the electrode would throw out drops of liquid. From this moment on the power of the bulb is tenfold, and at this stage it must always be kept to give the best results.

I may remark, however, that while it may be generally stated the Crookes vacuum is not high enough for the production of the Roentgen phenomena, this is not literally true. Nor are the Crookes phenomena produced at a particular degree of exhaustion, but manifest themselves even with [illegible], provided the potential is high enough. This is likewise true of the Roentgen effects. Naturally, to verify [illegible] must be made [illegible] the bulb when the potential [illegible]

(Concluded [illegible])

TESLA ON REFLECTED ROENTGEN RAYS

[illegible]

In previous [illegible] to your esteemed journal in regard to the effects discovered by [illegible] I have confined myself to giving barely a brief outline of the most noteworthy results arrived at in the course of my investigations. To state truthfully, I have ventured to express myself, the [illegible] time, after some hesitation and consequent delay, and only when I had gained the conviction that the information I had to convey was a needful one; for, in common with others, I was not quite able to free myself of a certain feeling which one must experience when he is trespassing on ground not belonging to him. The discoverer would naturally himself arrive at most of the facts in due time, and a courteous restraint in the announcement of the results on the part of his co-workers would not be amiss. How many have sinned against me by proclaiming their achievements just as I was good and ready to do it myself! But these discoveries of Roentgen, exactly of the order of the telescope and microscope, his seeing through a great thickness of an opaque substance, his recording on a sensitive plate of objects otherwise invisible, were so beautiful and fascinating, so full of promise, that all restraint was put aside, and every one abandoned himself to the pleasures of speculation and experiment. Would but every new and worthy idea find such an echo! One single year would then equal a century of progress. A delight it would be to live in such age, but a discoverer I would not wish to be.

Amongst the facts, which I have had the honor to bring to notice, is one claiming a large share of scientific interest, as well as of practical importance. I refer to the demonstration of the property of reflection, on which I have dwelt briefly.

Having had opportunities to make many observations during my experience with vacuum bulbs and tubes, which could not be accounted for in any plausible way on any theory of vibration as far as I could judge, I [illegible] investigations—disin- [illegible]

tom blown as thin a[illegible] the two obvious obj[illegible] the radiation to the [illegible] tating th[illegible] form of a round dis[illegible] slightly less than that of [illegible] was placed about an inch [illegible] narrow neck [illegible] on the top. The [illegible] ing in conductor c was provided [illegible] a long wrapping w, so as to p[illegible] cracking, by the formation of spa[illegible] at the point where the wire en[illegible] the bulb. It was found advantag[illegible] for a number of reasons to extend [illegible] wrapping a good distance beyond the neck, on the inside and outside as well, and to place the seal-off in the narrow neck. On other occasions I have dwelt on the employment of an electrostatic screen in connection with such single-terminal bulbs. In the present instance the screen was preferably formed by a bronze painting [illegible] slightly above the aluminum electrode and extending to just a little below the wrapping of the wire, so as to allow seeing constantly the end of the wrapping. Or else a small aluminum plate [illegible], Fig. 2, was supported in the inside of the bulb above the electrode. This static screen practically doubled the effect, as it prevented all action above it. Considering, further, the [illegible]

[illegible]

[illegible] during [illegible] the wrapping [illegible] small bright spark jump[illegible] to time from the wir[illegible] num plate [illegible] through the [illegible] The passage of this sp[illegible] gases to be formed, whi[illegible] impair the vacuum, and in [illegible] ner, by a little skillful m[illegible] the proper vacuum may be [illegible] maintained. Another [illegible] the same result in a tube shown in Fig. 1 is to extend the wrapping so far inside that, when the bulb is normally working, the wrapping is heated sufficiently to free gases to the [illegible] amount. It is for [illegible] to let th[illegible] bronze painting extend [illegible] below [illegible] wrapping, so th[illegible] [illegible] overcoming [illegible] difficulty [illegible] cause some [illegible] ance [illegible] with [illegible] should [illegible] that when [illegible] show the[illegible] there [illegible] from the [illegible] entirely [illegible] practically [illegible] tive plate alth[illegible] and [illegible] the bulb [illegible] out still th[illegible]

formance of this screen was particularly noteworthy. It was illuminated at a distance of 20 feet, and even at a distance of 40 feet I could still observe a faint shadow passing across the field of vision when moving the hand in front of the instrument. Looking at a distance of about three feet from the bulb through the body of an assistant, I could distinguish easily the spinal column in the upper part of the body, which was more transparent. In the lower part of the body the column and the rest were practically not perceptible. The ribs were only very faintly seen. The bones of the neck were plainly noticeable and I could see through the [illegible]

must be admitted that the performance of such a screen is [illegible] with the appliances I have used, I have, nevertheless, [illegible] of its still limited [illegible] purpose of [illegible] distinguish the bones [illegible] but not nearly as [illegible] photographic [illegible] Eventually, however, with the [illegible] of strong radiations and good reflectors, such fluorescent screens may become valuable instruments [illegible] investigation. A few [illegible] I observed a small screen [illegible] platino-cyanide [illegible] distance from the bulb, I [illegible] [illegible] that it might be [illegible] observe by the aid of such a [illegible] jects passing through a [illegible] possibility seems to me [illegible] at present than [illegible] Forty feet is a fair [illegible] and a screen lights up [illegible] distance from a single bulb [illegible] [illegible]

TESLA ON ROENTGEN RADIATIONS.

To the Editor of Electrical Review:

Having observed the unexpected behavior of the various metals in regard to the reflection of these radiations [illegible] located in your issue of April 1, I have endeavored to settle [illegible]

[illegible] get a sharp shadow we must take this distance not less than two feet, and I am finding it more and more necessary to adopt a still greater distance. If, for the sake of simplicity, we assume a spherical bulb and electrode, the radiation will be uniform on all sides, and any element of a surface of a sphere of radius D, drawn around the electrode, will receive an equal [illegible] The total surface [illegible]

[illegible] was lifted up so as to just expose the half-spherical bottom of the latter. The bulb was placed as exactly as it was practicable in the center, so that both halves of the reflecting plate were equally exposed to the radiations.

Having failed to obtain, in former experiments, a record for iron owing to an oversight, I tried to ascertain its position in the series by comparing it with copper, using a plate [illegible] iron and copper. The experiments showed that iron reflected about as much as copper, but which metal reflected better was im[illegible]

[illegible] above the former. The exact distance from the electrode to the [illegible] plate was four and one-half feet. The distance from the end of the tube to the plate was three and one-half feet. The exposure lasted [illegible] minutes. The plate showed very strongly and clearly every bone, [illegible] shoulder and ribs, but I can not tell how clearly they will appear [illegible] print. I selected the same object as in my first report in your columns on this investigation, so as to give a better idea of the progress [illegible] The advance will be best appreciated [illegible]

that in the instances mentioned before the angle of incidence was 45 degrees, and that for larger angles a much greater portion of the rays would be reflected. The exact law of reflection is still to be determined. Now, let us suppose the shadow of an object is taken at a distance, D. In order to [illegible]

[illegible] plate, so as to get fairly sharp outlines. [illegible]

TESLA ON ROENTGEN RADIATIONS.

[illegible]

Having observed the unexpected behavior of the various metals in regard to the reflection of these radiations, as communicated in your issue of April 1, I have endeavored to settle several still doubtful points. As, for the present, it appeared chiefly desirable to establish the exact order of the metals, or conductors, in regard [illegible] effects, I modified slightly the apparatus and procedure described in my communication just referred to. The reflecting plates were [illegible] This was done by fastening [illegible] metal [illegible] to be investigated, so that the reflecting surface was divided in two halves by the joining line. Furthermore, to prevent any crossing and mingling of the rays [illegible] from both halves, I divided [illegible] by a thick lead plate through the middle. Care was taken that the density of the rays falling upon the [illegible] and with the object [illegible] was lifted up so as to just expose the half-spherical bottom of the latter. The bulb was placed as exactly as it was practicable in the center, so that both halves of the reflecting plate [illegible]

Having failed to obtain, in former experiments, a record for iron owing [illegible] ing it with copper, using a plate made up of iron and copper. The experiments showed that iron reflected about as much as copper, but which metal reflected better was im-

get a sharp shadow we must take this distance not less than two feet, and I am finding it more and more necessary to adopt a still greater distance. If, for the sake of simplicity, we assume a spherical bulb and electrode, the radiation will be uniform on all sides, and any element of a surface of a sphere of radius D, drawn around the electrode, will receive an equal quantity of rays. The total surface of this sphere will be $4\pi D^2$. The object, the shadow of which is to be taken, may have a small area a, which gets only an insignificant part of the total rays emitted, this part being [illegible]

If D is very large and the object, that is, the area a, small, this ratio [illegible] by the use of a proper reflector we can easily concentrate upon the area an amount of rays [illegible] exceeding that which would fall upon it without the use of a reflector, in spite of the fact that we are able to reflect only a few per cent of the total incident rays.

As an evidence of the effectiveness of such a reflector, the annexed print of the shoulder and ribs of a man is shown. A funnel-shaped zinc reflector [illegible] high, with an opening of five inches on the bottom and 23 inches at the top, was used in the experiment. A tube similar in every [illegible] was [illegible] ded [illegible] The exact distance from the electrode to the sensitive plate was four and one-half feet. The distance from the end of the tube to the plate was three and one-half feet. The exposure lasted 40 minutes. The plate showed very strongly and clearly every bone, and shoulder and ribs, but I can not tell how clearly they will appear in the print. I selected the same object as in my first report in your columns on this investigation, so as to give a better idea of the progress made. The advance will be best appreciated

[illegible] was lifted up so as to just expose the half-spherical bottom of the latter. The bulb was placed as exactly as it was practicable in the center, so that both halves of the reflecting plate were equally exposed to the radiations.

Having failed to obtain, in former experiments, a record for iron owing to an oversight, I tried to ascertain its position in the series by comparing it with copper, using a plate made up of iron and copper. The experiments showed that iron reflected about as much as copper, but which metal reflected better was impossible to determine with safety by this method. Next I endeavored to find whether tin or lead was a better reflector, by the same method. Three experiments were performed, and in each case the metals behaved nearly alike, but tin appeared just a trifle better. Finally I investigated the properties of magnesium as compared with zinc. In fact, the experiments showed that magnesium reflected a little better.

I am not yet satisfied, in view of the importance of this relation of the metals with the means employed, and will try to devise an apparatus which will do away with all the defects of the present. The time of the exposure I have found practicable to reduce to a few minutes by the help of a fluorescent paper.

In my previous communications I have barely hinted at the practical importance of the use of suitable reflectors. One would be apt to conclude that, since, under the conditions of the previously described experiments, zinc, for instance, reflected only three per cent of the incident rays, the gain secured by the employment of such zinc reflector would be small. This, of course, would be an erroneous conclusion. First of all it should be remembered that in the instances mentioned before the angle of incidence was 45 degrees, and that for larger angles a much greater portion of the rays would be reflected. The exact law of reflection is still to be determined. Now, let us suppose the shadow of an object is taken at a distance, D. In order to

[illegible] above the former. The exact distance from the electrode to the sensitive plate was four and one-half feet. The distance from the end of the tube to the plate was three and one-half feet. The exposure lasted 40 minutes. The plate showed very strongly and clearly every bone, and shoulder and ribs, but I can not tell how clearly they will appear in the print. I selected the same object as in my first report in your columns on this investigation, so as to give a better idea of the progress made. The advance will be best appreciated by stating that the distance in this case was much more than double, while the time of exposure was less than one-half. The chief importance of a reflector consists, however, in this, that it allows the use of many bulbs without sacrifice of precision and clearness, and also the concentration of a great quantity of radiation upon a very small area.

Since the use of phosphorescent or fluorescent bodies in connection with the sensitive film has been suggested by Professors Henry and Salvioni, I have found it an easy matter to shorten the time of exposure to a few minutes, or even seconds. So far, it seems that the tungstate of calcium, recently introduced by Edison, and manufactured by Messrs. Aylsworth & Jackson, is the most sensitive body. I obtained a sample of it and used it in a series of tests. It fluoresces decidedly better than barium-platino-cyanide, but, owing to the size of the crystals and necessarily uneven distribution on the paper, it does not leave a clean impression. For use in connection with the sensitive films, it should be ground very fine, and some way should be adopted of distributing it uniformly. The paper also must adhere firmly [illegible] plate, so as [illegible] lines. The [illegible] seems to depend on [illegible] tion, because I [illegible] several bulbs which otherwise worked excellently without producing a very good result, and I almost gained a false impression. One or two of the [illegible]

(Concluded on page [illegible])

TESLA ON ROENTGEN RADIATIONS.

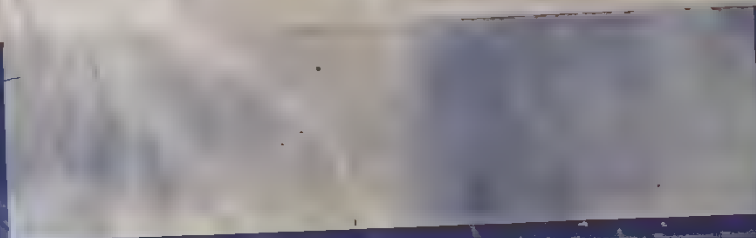
(Concluded from page 1[illegible].)

ever, effected it very powerfully. An impression of the hand was taken at a distance of about six feet from the bulb with an exposure of less than one minute, and even then it was found that the plate was overexposed. I then took an impression of the chest of a man at a distance of 12 feet from the end of the tube, exposing five minutes. The developed plate showed the ribs clearly, but the outlines were not sharp. Next, I employed a tube with a zinc reflector, as before described, taking an impression of the chest of an assistant at a distance of four feet from the bulb.

for these ominous signs and insta[illegible] reduce the potential. Owing to [illegible] untimely end of the bulb [illegible] described experiment, t[illegible] lasted only one minute. [illegible] a very strong impression [illegible] ton of the chest, show[illegible] and left ribs and other [illegible] obtained. The outlin[illegible] were again much less [illegible] when the ordinary proce[illegible] the phosphorescent inte[illegible] followed, although care was [illegible] press the fluorescent pa[illegible] against the film. From th[illegible] it is evident that, when [illegible] above means for shortening [illegible] of exposure, the thickn[illegible]

[illegible] creen was particu- [illegible] It was illuminated [illegible] and even at a [illegible] uld still observe [illegible] across the [illegible] oving the hand [illegible] nt. Looking [illegible] hree feet from [illegible] body of an [illegible] guish easily [illegible] upper part [illegible] more trans- [illegible] part of the [illegible] The [illegible] The [illegible] only notice- [illegible] rough the

(N.Y.) APR 3 1896



The latter w... much in th...
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...kiaproscope with the lens
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...for a long
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on the screen. In one instance the pe...

...moved up and down ...
the bulb. When looking through
and I could observe only the outline
of the skull and the ...
the field of vision was still ...
Everything else appeared ...
This shows that ...
...will not aid us very much
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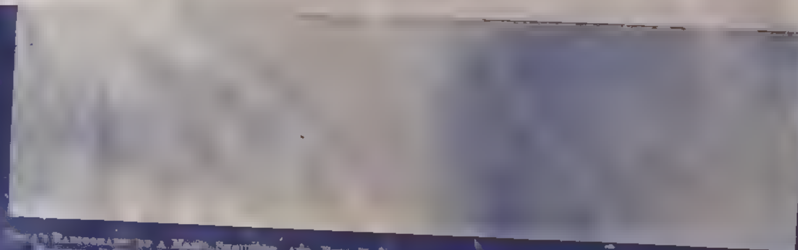

[illegible] activity and vapo[illegible] of the gas in the bulb [illegible] latter. The [illegible]

[illegible] of tungstate of calcium [illegible] the effect upon a fluorescent screen made of this chemical. Such a screen together with a paper box [illegible] fluoroscope. [illegible] is a great dis[illegible] to work [illegible]

[illegible] moved up and down [illegible] the bulb. When looking through the [illegible] I could observe only the outline of the skull and the [illegible] the field of vision was still [illegible] everything else appeared [illegible] This shows that [illegible] will not aid us very much in the examination of the internal parts of the body. [illegible] come through the production of [illegible] powerful radiations [illegible] indicated the right [illegible]

saving in its manufacturing cost besides securing other and equally important advantages.

Tesla's latest investigations of the many interesting scientific questions arising from the Roentgen ray discovery are published in this issue. No step in the various stages that he has so far presented to the readers of the ELECTRICAL REVIEW is more interesting or suggestive. The relation which he demonstrates to exist between the series obtained by arranging the metals according to their reflective power and Volta's contact series in air, proves that the rays emitted from the bulb are not an isolated phenomenon, but are emitted everywhere. Particularly suggestive is the observation that all conductors emit streams similar to those discovered by Roentgen, and that th[illegible] sun and other sources of radiant energies must pour forth rays of the nature of the cathode. To those devoted chiefly to the practical applications of Roentgen's discovery, Tesla's latest observations with [illegible] fluorescent screen, showing that even the heart can be seen, will appear most promising, while his investigation of the important effect discovered by Prof. J. [illegible] Thomson (who has contributed so much to the advancement along these lines) can not fail [illegible] t interest to [illegible]

[illegible]

TESLA'S LATEST ROENTGEN RAY INVESTIGATIONS.

To the Editor of Electrical [illegible]

Further investigations concerning the behavior of the various metals in regard to reflection of these radiations have given additional support to the opinion which I have before expressed, namely, that Volta's electric cont[illegible] series in air is identical with th[illegible] which is obtained when arranging the metals according to their powers of reflection, the most electro-p[illegible] metal being the best reflector [illegible] fining myself to the metals easily experimented upon, this series is magnesium, lead, tin, iron, copper, silver, gold and platinum. The last named metal should be found to be the poorest, and sodium one of th[illegible] best reflectors. This relation is rendered still more interesting and su[illegible] gestive when we consider that this series is approximately the sam[illegible] which is obtained when arranging the metals according to their energies of combination with oxygen, as calculated from their chemical equivalents.

Should the above [illegible] firmed by other physicists, [illegible] justified to draw the foll[illegible] clusions: *First*, the highly [illegible] bulb emits material [illegible] impinging on a metallic [illegible] reflected; *second*, [illegible] formed [illegible] or elem[illegible] material streams [illegible] same agent which [illegible] electro-mo[illegible]

[illegible]

dence of that kind is, to say the least, extremely improbable. Besides, the fact may be cited that there is always a difference of potential set up between two metal plates at some distance and in the path of the rays issuing from an exhausted bulb.

Now, since there exists an electric pressure or difference of potential between two metals in close proximity or contact, we must, when considering all the foregoing, come to the fourth conclusion, namely, that the metals emit similar streams, and I therefore anticipate that, if a sensitive film be placed between two plates, say, of magnesium and copper, a true Roentgen shadow picture would be obtained after a very long exposure in the dark. Or, in general, such picture could be secured whenever the plate is placed near a metallic or conducting body, leaving for the present the insulators out of consideration. Sodium, one of the first of the electric contact series, but not yet experimented upon, should give out more of such streams than even magnesium.

Obviously, such streams could not be forever emitted, unless there is a continuous supply of radiation from the medium in some other form; or possibly the streams which the bodies themselves emit are merely reflected streams coming from other sources. But since all investigation has strengthened the opinion advanced by Roentgen that for the production of these radiations some impact is required, the former of the two possibilities is the more probable one, and we must assume that the radiations existing in the medium and giving rise to those here considered partake something of the nature of cathodic streams.

But if such streams exist all around us in the ambient medium, the question arises, whence do they come? The only answer is: From the sun. I infer, therefore, that the sun and other sources of radiant energy must, in a less degree, emit radiations or streams of matter similar to those thrown off by an electrode in a highly exhausted inclosure. This seems to be, at this moment, still a point of controversy. According to my present convictions a Roentgen shadow picture should, with very long exposures, be obtained from all sources of radiant energy, provided the radiations are permitted first to impinge upon a metal or other body.

The preceding considerations tend to show that the lumps of matter composing a cathodic stream in the difference was noted in any case. I therefore conclude that the matter composing the Roentgen rays does not suffer further degradation by impact against bodies. One of the most important tasks for the experimenter remains still to determine what becomes of the energy of these rays. In a number of experiments with rays reflected from and transmitted through a conducting or insulating plate, I found that only a small part of the rays could be accounted for. For instance, through a zinc plate, one-sixteenth of an inch thick, under an incident angle of 45 degrees, about two and one-half per cent were reflected and about three per cent transmitted through the plate, hence over 94 per cent of the total radiation remain to be accounted for. All the tests which I have been able to make have confirmed Roentgen's statement that these rays are incapable of raising the temperature of a body. To trace this lost energy and account for it in a plausible way will be equivalent to making a new discovery.

Since it is now demonstrated that all bodies reflect more or less, the diffusion through the air is easily accounted for. Observing the tendency to scatter through the air, I have been led to increase the efficiency of reflectors by providing not one, but separated successive layers for reflection, by making the reflector of thin sheets of metal, mica or other substances. The efficiency of mica as a reflector I attribute chiefly to the fact that it is composed of many superimposed layers which reflect individually. These many successive reflections are, in my opinion, also the cause of the scattering through the air.

In my communication to you of April 1, I have for the first time stated that these rays are composed of matter in a "primary" or elementary condition or state. I have chosen this mode of expression in order to avoid the use of the word "ether," which is usually understood in the sense of the Maxwellian interpretation, which would not be in accord with my present convictions in regard to the nature of the radiations.

An observation which might be of some interest is the following: A few years ago I described on one occasion a phenomenon observed in highly exhausted bulbs. It is a brush or stream issuing from a single electrode under certain conditions, which rotates very rapidly in consequence of the action of the earth's magnetism. Now I have recently observed duced with a steady difference of pressure as from a battery, with the exclusion of all vibration, which may occur, even in such instance, as has been pointed out by De La Rive. In my experiments I have tried to ascertain whether a greater difference between the shadows of the bones and flesh could be obtained by employing currents of extremely high frequency, but I have been unable to discover any such effect which would be dependent on the frequency of the currents, although the latter were varied between as wide limits as was possible. But it is a rule that the more intense the action the sharper the shadows obtained, provided that the distance is not too small. It is furthermore of the greatest importance for the clearness of the shadows that the rays should be passed through some tubular reflector, which renders them sensibly parallel.

In order then to bring out as much detail as possible on a sensitive plate, we have to proceed in precisely the same way as if we had to deal with flying bullets hitting against a wall composed of parts of different density, with the problem before us of producing as large as possible a difference in the trajectories of the bullets which pass through the various parts of the wall. Manifestly, this difference will be the greater the greater the velocity of the bullets; hence, in order to bring out detail, very strong radiations are required. Proceeding on this theory I have employed exceptionally thick films and developed very slowly, and in this way clearer pictures have been obtained. The importance of slow development has been first pointed out by Professor Wright, of Yale. Of course, if Professor Henry's suggestion of the use of a fluorescent body in contact with the sensitive film is made use of, the process is reduced to an ordinary quick photographic procedure, and the above consideration does not apply.

It being desirable to produce as powerful a radiation as possible, I have continued to devote my attention to this problem and have been quite successful. First of all, there existed limitations in the vacuum tube which did not permit the applying of as high a potential as I desired, namely, when a certain high degree of exhaustion was reached a spark would form behind the electrode, which would prevent straining the tube much higher. This inconvenience I have overcome entirely by making the wire leading to the electrode very long and passing it through

TESLA'S LATEST ROENTGEN RAY INVESTIGATIONS.

(Concluded from page 207.)

thick glass tube *t*. The tube was closed in front by a diaphragm *d* of pergament, and by a rubber plug P in the back. The plug was provided with two holes, into the lower one of which a glass tube *g*, reaching to very nearly the end of the bulb, was inserted. Oil of some kind was made to flow through rubber tubes *r r* from a large reservoir R, placed on an adjustable support S, to the lower reservoir R, the path of the oil being clearly observable from the drawing.

By adjusting the difference of the level between the two reservoirs it was easy to maintain a permanent condition of working. The outer glass tube *t* served in part as a reflector, while at the same time it permitted the observation of the bulb *b* during the action. The plug P, in which the conductor *c* was tightly sealed, was so arranged that it could be shifted in and out of the tube *t*, so as to vary the thickness of the oil traversed by the rays.

I have obtained some results with this apparatus which clearly show the advantage of such disposition. For instance, at a distance of 45 feet from the end of the bulb my assistants and myself could observe clearly the fingers of the hand through a screen of tungstate of calcium, the rays traversing about two and one-half inches of oil and the diaphragm *d*. It is practicable with such apparatus to make photographs of small objects at a distance of 40 feet with only a few minutes exposure, by the help of Professor Henry's method. But, even without the use of a fluorescent powder, short exposures are practicable, so that I think the use of the above method is not essential for shadows has been proposed to me by Mr. E. R. Hewitt. He assumed that the absence of sharpness of the outlines in the shadows on the screen was due to the spread of the fluorescence from crystal to crystal. He proposed to avoid this by using a thin aluminium plate with many parallel grooves. Acting on this suggestion, I made some experiments with wire gauze, and, furthermore, with screens made of a mixture of a fluorescent with a non-fluorescent powder. I found that the general brightness of the screen was diminished, but that with a strong radiation the shadows appeared sharper. This idea might be found capable of useful application.

By the use of the above apparatus I have been enabled to examine much better than before the body by means of the fluorescent screen. Presently the vertebral column can be seen quite clearly, even in the lower part of the body. I have also clearly noted the outlines of the hip bones. Looking in the region of the heart I have been able to locate it unmistakably. The background appeared much brighter, and this difference in the intensity of the shadow and surrounding has surprised me. The ribs I could now see on a number of occasions quite distinctly, as well as the shoulder bones. Of course, there is no difficulty whatever in observing the bones of all limbs. I noted certain peculiar effects which I attribute to the oil. For instance, the rays passed through plates of metal over one-eighth of an inch thick, and in one instance I could see quite clearly the bones of my hand through sheets of copper, iron and brass of a thickness of nearly one-quarter of an inch. Through glass the rays seemed to pass with such freedom that, looking through the screen in a direction at right angles to the axis of the tube, the action was most intense, although the rays had to pass through a great thickness of glass and oil. A glass slab nearly one-half of an inch thick, held in front of the screen, hardly dimmed the fluorescence. When holding the screen in front of the tube at a distance of about three feet, the head of an assistant, thrust between the screen and the tube, cast but a feeble shadow. It appeared some times as if the bones and the flesh were equally transparent to the radiations passing through the oil. When very close to the bulb, the screen was illuminated through the body of an assistant so strongly that, when a hand was moved in front, I could clearly note

During my study of the behavior of oils and other liquid insulators, which I am still continuing, it has occurred to me to investigate the important effect discovered by Prof. J. J. Thomson. He announced some time ago that all bodies traversed by Roentgen radiations become conductors of electricity. I applied a sensitive resonance test to the investigation of this phenomenon in a manner pointed out in my earlier writings on high frequency currents. A secondary, preferably not in very close inductive relation to the primary circuit, was connected to the latter and to the ground, and the vibration through the primary was so adjusted that true resonance took place. As the secondary had a considerable number of turns, very small bodies attached to the free terminal produced considerable variations of potential on the latter. Placing a tube in a box of wood filled with oil and attaching it to the terminal, I adjusted the vibration through the primary so that resonance took place without the bulb radiating Roentgen rays to an appreciable extent. I then changed the conditions so that the bulb became very active in the production of the rays. The oil should have now, according to Prof. J. J. Thomson's statement, become a conductor and a very marked change in the vibration should have occurred. This was found not to be the case, so that we must see in the phenomenon discovered by J. J. Thomson only a further evidence that we have to deal here with streams of matter which, traversing the bodies, carry away electrical charges. But the bodies do not become conductors in the common acceptance of the term. The method I have followed is so delicate that a mistake is almost an impossibility.

NIKOLA TESLA.

New York, April 20.

Law Battery Company Burned Out.

The new plant of the Law Battery Company, at Cranford, N. J., was burned out on April 16. The heavy machinery was not damaged and the other losses are fully covered by insurance. The company is prepared to fill orders as usual.

New Telephone and Telegraph Companies.

CHEROKEE, IOWA—The Cherokee Telephone Company has been incor-

[illegible] be shifted in and out of the tube A, so as to vary the thickness of the oil traversed by the rays.

I have obtained some results with this apparatus which clearly show the advantage of such disposition. For instance, at a distance of 45 feet from the end of the bulb my assistants and myself could observe clearly the fingers of the hand through a screen of tungstate of calcium, the rays traversing about two and one-half inches of oil and the diaphragm *d*. It is practicable with such apparatus to make photographs of small objects at a distance of 40 feet, with only a few minutes exposure, by the help of Professor Henry's method. But, even without the use of a fluorescent powder, short exposures are practicable, so that I think the use of the above method is not essential for quick procedure. I rather believe that in the practical development of this principle, if it shall be necessary, Professor Salvioni's suggestion of a fluorescent emulsion, combined with a film, will have to be adopted. This is bound to give better results than an independent fluorescent screen, and will very much simplify the process. I may say, however, that, since my last communication, considerable improvement has been made in the screens. The manufacturers of Edison's tungstate of calcium are now furnishing screens which give fairly clean pictures. The powder is fine and it is more uniformly distributed. I consider, also, that the employment of a softer and thicker paper than before is of advantage. It is just to remark that the tungstate of calcium has also proved to be an excellent fluorescent in the bulb. I tested its qualities for such use immediately and find it so far unexcelled. Whether it will be so for a long time remains to be seen. News reaches us that several fluorescent bodies, better than the cyanides, have been discovered abroad.

Another improvement with a view of increasing the sharpness of the [illegible] to pass with such freedom [illegible], issuing through the screen in a direction at right angles to the axis of the tube, the action was most intense, although the rays had to pass through a great thickness of glass and oil. A glass slab nearly one-half of an inch thick, held in front of the screen, hardly dimmed the fluorescence. When holding the screen in front of the tube at a distance of about three feet, the head of an assistant, thrust between the screen and the tube, cast but a feeble shadow. It appeared some times as if the bones and the flesh were equally transparent to the radiations passing through the oil. When very close to the bulb, the screen was illuminated through the body of an assistant so strongly that, when a hand was moved in front, I could clearly note the motion of the hand through the body. In one instance I could even distinguish the bones of the arm.

Having observed the extraordinary transparence of the bones in some instances, I at first surmised that the rays might be vibrations of high pitch, and that the oil had in some way absorbed a part of them. This view, however, became untenable when I found that at a certain distance from the bulb I obtained a sharp shadow of the bones. This latter observation led me to apply usefully the screen in taking impressions on the plate. Namely, in such case it is of advantage to first determine by means of the screen the proper distance at which the object is to be placed before taking the impression. It will be found that often the image is much clearer at a greater distance. In order to avoid any error when observing with the screen I have surrounded the [illegible] with thick metal plates, so as to prevent the fluorescence, in consequence of the radiations, reaching the screen from the sides. I believe that such an arrangement is absolutely necessary if one wishes to make correct observations.

I have followed [illegible]
mistakes almo[illegible]

New York, A[illegible]

Law Battery [illegible]

The new pla[illegible]
Company, at [illegible]
burned out on [illegible]
machinery wa[illegible]
other losses a[illegible]
surance. The[illegible]
to fill orders [illegible]

New Teleph[illegible]
C[illegible]

CHELSEA, [illegible]
Telephone Co[illegible]
porated by Ja[illegible]
Robie, A. B. [illegible]
and W. A. [illegible]
$25,000.

CHELSEA, [illegible]
Telephone Co[illegible]
incorporated [illegible]
Henry G[illegible]
others. [illegible]

WARREN, V[illegible]
to be put [illegible]
Roxbury, and [illegible]
nected with t[illegible]

INDIANAPO[illegible]
Point Teleph[illegible]
incorporated. [illegible]
George W. P[illegible]

[illegible] that the [illegible]
[illegible] intends [illegible]
Freeport to [illegible]
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company is [illegible]
facility for a [illegible]

[illegible] or other body.

The preceding considerations tend [illegible] the lumps of matter [illegible] cathodic stream in the [illegible] up into incompar- [illegible] by impact [illegible] the wall of the [illegible] and, [illegible] are enabled to pass [illegible] the [illegible]. All evidence which [illegible] so far obtained points rather to this [illegible] the throwing off of particles [illegible] under the violent [illegible] cathodic stream. According to my convictions [illegible] the difference between Lenard and Roentgen [illegible] [illegible] the [illegible] [illegible] only the rays discovered [illegible] are much more effective. [illegible] that these rays are pro- [illegible] exceptional con- [illegible] bulb, the vacuum being [illegible] and that the range [illegible] purpose in view, but so marked [illegible]

[illegible] or stream issuing from a single elec- trode under certain conditions, which rotates very rapidly in consequence of the [illegible] of the earth's magnet- ism. Now [illegible] have recently observed this [illegible] in several bulbs which [illegible] capable of [illegible] the [illegible] film and [illegible] very strongly. As [illegible] rapidly turning around [illegible] conjectured that perhaps also [illegible] Roentgen streams [illegible] rotating under the action of the earth's magnetism, and I endeavored [illegible] to obtain an evidence of [illegible] motion by studying the [illegible] of [illegible] bulb in various positions with [illegible] to the magnetic axis of the earth. [illegible] so far as the vibrational [illegible] the rays [illegible] concerned [illegible] that the vibration is merely that [illegible] is conditioned by the apparatus employed. With the ordinary [illegible] coil [illegible] have almost [illegible] very low [illegible] by the commutator [illegible] the disruptive device or break [illegible] coil we usually have a very strong superimposed vibration in addition to the fundamental one, and it is [illegible] to trace sometimes as much as [illegible] the fourth [illegible] vibration [illegible] myself [illegible] approximation [illegible] of light [illegible] these effects could be as well pro-

which would prevent [illegible] take much higher. This [illegible] I have [illegible] making the wire leading [illegible] trode very long and passing it through a narrow channel, so that the [illegible] electrode could not [illegible] the formation of such sparks [illegible] other limitation [illegible] would break [illegible] at the end of the tube [illegible] potential was excessive. This [illegible] inconvenience I have overcome [illegible] the use of [illegible] the tube, as I have [illegible] before [illegible] in oil. The oil [illegible] well known, is a means [illegible] impossible the formation [illegible] by the exclusion of all air. The [illegible] of the oil in connection with the [illegible] duction of these radiations [illegible] early advocated in this country by Pro- fessor Trowbridge. Originally [illegible] employed a wooden box made [illegible] oughly tight with wax and filled [illegible] oil or other liquid, in which the [illegible] was immersed. Observing [illegible] actions, I modified [illegible] the apparatus, and in later investigations I have employed an arrangement as shown in the [illegible] [illegible] out. A bulb [illegible] described before, with [illegible] leading wire and neck much longer than here shown, was inserted into a large and [illegible]

(Concluded on page [illegible].)

[illegible] in o[illegible] [illegible] Co[illegible] incl[illegible] [illegible],000, [illegible] [illegible] pal ra[illegible]

1896

justified to draw the following conclusions: *First*, the highly exhausted bulb emits material streams which, impinging on a metallic surface, are reflected; *second*, these streams are formed of matter in some primary or elementary condition; *third*, these material streams are probably the same agent which is the cause of the electro-motive tension between metals in close proximity or actual contact, and they may possibly, to some extent, determine the energy of combination of the metals with oxygen; *fourth*, every metal or conductor is more or less a source of such streams; *fifth*, these streams or radiations must be produced by some radiations which exist in the medium; and *sixth*, streams resembling the cathodic must be emitted by the sun and probably also by other sources of radiant energy, such as an arc light or Bunsen burner.

The first of these conclusions, assuming the above-cited fact to be correct, is evident and uncontrovertible. No theory of vibration of any kind would account for this singular relation between the powers of reflection and electric properties of the metals. Streams of projected matter coming in actual contact with the reflecting metal surface afford the only plausible explanation.

The second conclusion is likewise obvious, since no difference whatever is observed by employing various qualities of glass for the bulb, electrodes of different [illegible] [illegible] of residual [illegible] [illegible] the ma[illegible] constituting the streams may [illegible] undergo a change in the process of [illegible] or, generally speaking, projection—since the views in this regard still differ—in such [illegible] entirely the characteristics [illegible] possessed when forming the electrode or wall of the bulb, or the [illegible] contents of the latter.

The existence of the above relation between the reflecting and contact series forces us likewise to the third conclusion, because a mere coinci-

Adams; [illegible] the queer coil to that negotiations had been [illegible]

[illegible] IN THE LABORATORY [illegible] OBTAINED BY AN EXPOSURE OF TWO [illegible] THE LIGHT OF A SINGLE VACUUM TUBE WITHOUT ELECTRODES, HAVING A VOLUME OF ABOUT 20 CUBIC INCHES, GIVING APPROXIMATELY A [illegible] CANDLE-POWER—PHOTOGRAPHED BY TONNELÉ & CO. COPY[illegible] BY THE "ELECTRICAL REVIEW."

[illegible] Mr. Tesla [illegible]ingly [illegible] that it was [illegible] don[illegible] all of [illegible] his laboratory, [illegible] [illegible] in his [illegible]

Mr. Tesla [illegible] that [illegible] had [illegible] extra[illegible]

for the removal of the company's works from Schenectady, but that these had been dropped for the present. Mr. Coffin further stated that the patent agreement with the Westinghouse company will go into effect June [illegible]. It will not change the style or character of apparatus manufactured at the works in any [illegible] respect. The patent

TESLA'S IMPORTANT ADV[illegible]

HIS REMARKABLE ACHIEVEMENT[illegible] VACUUM TUBE LIGHTING.

A representative of the ELECTRICAL REVIEW visited the laboratory of Mr. Tesla last week and found him engaged in putting the final touches to certain improvements in vacuum tube illumination. He was enthusiastic as to the results arrived at to such a degree that he expressed his positive confidence as to having made very important advances.

While reluctant to speak at present extensively on the subject of his most recent investigations, he authorized the statement to the effect that he has been most successful in several lines of work he has been following up for a long time, only temporarily interrupted by the lamented destruction of his laboratory by fire about a year ago.

When asked about his often-mentioned oscillator he said that a commercial machine is now being completed with which he expects to show the superiority of this mode of generating electricity.

He further stated with evident elation that in the study of the Roentgen phenomenon he has made great progress, so much so that he is now able to perceive through an Edison improved Roentgen screen recently purchased from Aylsworth & Jackson, of this city, the heart of an assistant so clearly as to note its expansions and contractions. In some instances he could locate evident defects in the lungs of a number of persons.

As to his continuous efforts to improve his system of lighting by vacuum tubes, with which he has been identified during a number of years, Tesla said that he has been more successful than he had ever dared to hope. His [illegible]

[illegible] two years ago.

When asked, Mr [illegible] explanation of the picture, speaking with deep feeling, that the volume he was reading was one of the "Scientific Papers" of Maxwell, given to him as a token of friendship by Professor Dewar; the chair a gift of his warmest friend, Mr. E. D. Adams; and as to the queer coil to [illegible]

[illegible] left, Mr. Tesla hesit[illegible]

[illegible] Y., on May [illegible]. The representation of stock was 201,000 shares. George [illegible] elected a director in place [illegible] K. Cummings [illegible] the old board of directors [illegible] elected. Only routine [illegible] transacted and the question [illegible] impairment was not brought [illegible]

President Charles A. C[illegible] General Electric Company [illegible] by one of the editors [illegible] *Street Journal* recently [illegible] stated that negotiations had been [illegible]

[Tes]la in His Laboratory—Portrait Obtained by [illegible] Exposure of Two Seconds to the Light of a Single Vacuum Tube without Electrodes, Having a Volume of About 90 Cubic Inches, Giving Approximately a Light of 250 Candle-Power.—Photographed by Tonnele & Co. Copyrighted by the Electrical Review.

the outset closely followed the promising work of Nikola Tesla. We had the privilege of announcing in 1886, for the first time, Tesla's investigations in a system of electric lighting. Early in 1888 we were the first to announce his epochal discovery of the multiphase system of power transmission, and since that time it has been our pleasant duty to keep our readers well informed on the various subjects of his important researches, of which we only mention his contributions to the great discovery of Roentgen, which were exclusively published in our columns. It is, therefore, no small satisfaction for us to now first record another significant advance of this indefatigable worker. Ever since Tesla showed in his memorable lecture before the American Institute of Electrical Engineers, five years ago, the fascinating experiments with vacuum tubes, he has untiringly labored on, simplifying and improving his methods, not for a moment diverted by other tasks—nor even discouraged by so great a calamity as the recent destruction of his laboratory—from the problem of producing an efficient and practical system of electrical illumination.

No more impressive result of Tesla's earnest efforts could be shown than that which is outlined in our present issue. The portrait of the great inventor, which, especially in view of the extraordinary way in which it was obtained will not fail to interest the scientific world, is a striking illustration of what he has done. Surely, since he has produced a vacuum tube which is capable of supplying any volume of light desired, even more than a powerful arc light, we can not hesitate to express our positive conviction that the introduction of a more perfect illuminant is near at hand.

tified during a number of years, said that he has been more successful than he had ever dared to hope.

The ELECTRICAL REVIEW has from the outset closely followed the promising work of Nikola Tesla. We had the privilege of announcing in 1886, for the first time, Tesla's investigations in a system of electric lighting. Early in 1888 we were the first to announce his epochal discovery of the multiphase system of power transmission, and since that time it has been our pleasant duty to keep our readers well informed on the various subjects of his important researches,

... with which he has been identified during a number of years, Tesla said that he has been more successful than he had ever dared to hope. His methods of conversion from ordinary to high-frequency currents are rendered simple in the extreme, the devices are thoroughly reliable and require no attention. Last, but most important of all, he has succeeded in increasing the candle-power of the tubes to practically any intensity desired.

A remarkable and most telling result of the advances he has made in the last direction is a portrait, which he has reluctantly allowed us to use, and which was obtained by *two seconds'* exposure to the light of a *single vacuum tube* of small dimensions. Tesla stated further that photographs obtained by the light of such powerful tubes show an amount of detail which no picture taken by the sun or flash light is capable of disclosing. This feature it only

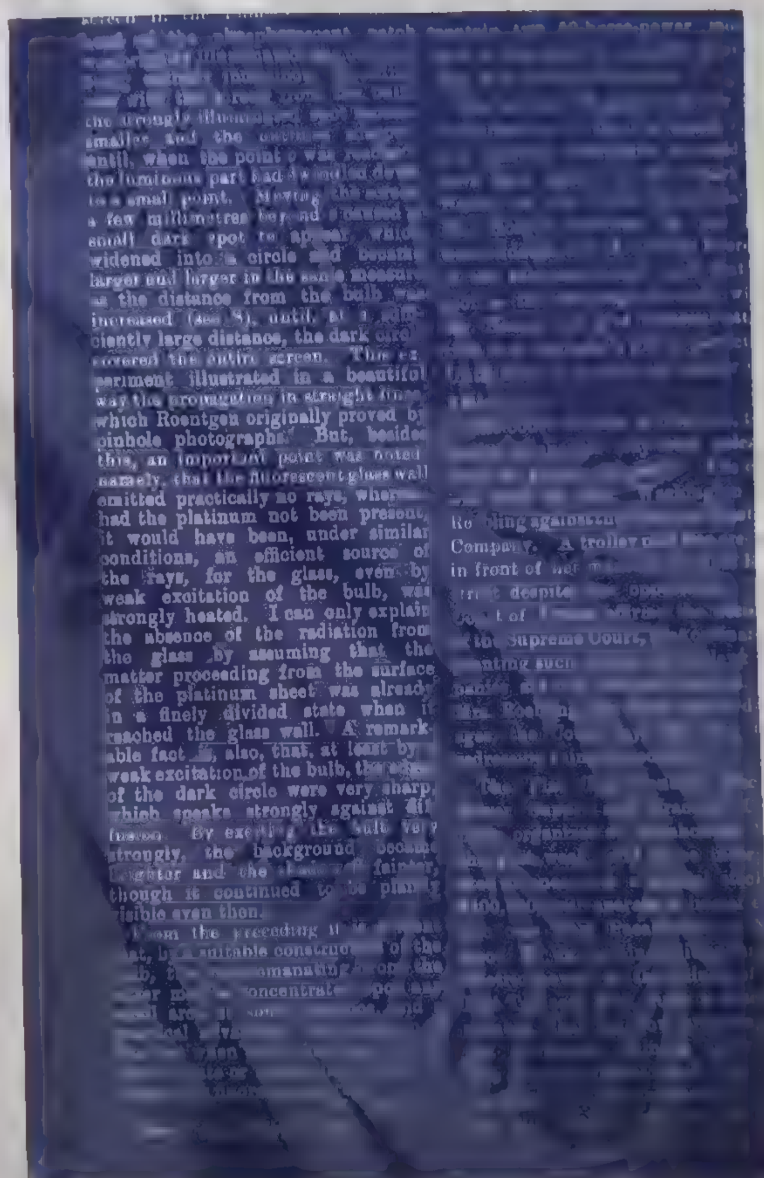
... ordinary manner in which the photograph was taken, he would not have given this explanation even to such an important personage as the representative of the ELECTRICAL REVIEW.

The *Western Electrician* felicitates itself on getting its issue of May 9 to New York on May 2. This western enterprise is a question merely of dating ahead—and because of the news and up-to-date information that does not, but should, appear appeals solely to the amiable minds to be found in the editorial office of our blue-countenanced contemporary.

... Westinghouse company will go into effect June 1. It will not change the style or character of apparatus manufactured at the works in any substantial respect. The patent agreement has been under consideration long enough to warrant the belief that it will result in a considerable increase in business for the two companies and a much better prices. The directors have not, for various reasons, formulated any definite plan for correcting the impairment of capital. The preferred shareholders have recently taken up the question for formal consideration and it is not impossible that some plan of dealing with the matter may be outlined at an early date.

Mr. W. J. Camp, of Montreal, electrician of the Canadian Pacific Telegraph, was a New York visitor last week, conferring with Electrician F. W. Jones, of the Postal Telegraph.

... was obtained will not fail to interest the scientific world, is a striking illustration of what he has done. Surely, since he has produced a vacuum tube which is capable of supplying any volume of light desired, even more than a powerful arc light, we can not hesitate to express our positive conviction that the introduction of a more perfect illuminant is near at hand.



[illegible] the strongly illuminated [illegible] smaller and the [illegible] until, when the point o was [illegible] the luminous part had dwindled [illegible] to a small point. Moving [illegible] a few millimetres beyond [illegible] small dark spot to appear, which widened into a circle and became larger and larger in the same measure as the distance from the bulb was increased (see S), until, at a sufficiently large distance, the dark circle covered the entire screen. This experiment illustrated in a beautiful way the propagation in straight lines which Roentgen originally proved by pinhole photographs. But, besides this, an important point was noted, namely, that the fluorescent glass wall emitted practically no rays, whereas, had the platinum not been present, it would have been, under similar conditions, an efficient source of the rays, for the glass, even by weak excitation of the bulb, was strongly heated. I can only explain the absence of the radiation from the glass by assuming that the matter proceeding from the surface of the platinum sheet was already in a finely divided state when it reached the glass wall. A remarkable fact is, also, that, at least by weak excitation of the bulb, the [illegible] of the dark circle were very sharp, which speaks strongly against diffusion. By exciting the bulb very strongly, the background became brighter and the shadow [illegible] fainter, though it continued to be plainly visible even then.

From the preceding [illegible] that, by a suitable construction of the bulb, [illegible] emanating [illegible] concentrated [illegible]

[illegible]

Re[illegible] against [illegible] Company. A trolley [illegible] in front of her [illegible] despite [illegible] the Supreme Court, [illegible]

[illegible] command of photography is another of his accomplishments.

An insulating material for wires is manufactured by Anderson, of Stockholm, by treating a fatty oil—such as resin oil—with 20 to 30 per cent of concentrated sulphuric acid at a low temperature. To this is added cellulose or moistened cotton, and the whole is heated to 140 degrees centigrade, and pulverized sulphur is added, which is followed by a reaction which completely changes the consistency of the material. A further large quantity of sulphur is added, and the material is then poured into cold water, after which it is rolled between cylinders and combined with rubber, gutta-percha, resin or paraffine, according to the purpose for which it is to be used.

There have been several peculiar trolley accidents in Brooklyn recently. In one instance a young lady had her jawbone broken by the end of the pole of a beer wagon, tearing her face horribly. Again, a boy, frightened by the burning out of a fuse, jumped off the car and was severely cut. He is suing for $5,000 damages.

One Thomas S. Wentworth is president of the South Peacock Mining Company, organized in Berwick, Me., with a capital of $500,000, of which $35 is paid in, to carry on a mining and electric light and power plant. This Peacock company can't do much strutting until some more cash is paid in.

The "Bridging Bell" Patent.

To the Editor of Electrical Review:

Will you kindly inform me through the columns of your valuable paper or by mail whether the "bridge bell" or method of connecting telephones "in multiple" is covered by patent?

I have seen many inquiries of this kind in your paper and, therefore, venture to ask this.

[illegible] Lord.

Limerick, Me., [illegible]

This patent is owned by the Western Electric Company, New York and Chicago.

[illegible]LA DESCRIBES AN INTERESTING FEATURE OF THE X-RAY RADIATIONS.

To the Editor of Electrical Review:

The following observations, made with bulbs emitting Roentgen radiations, may be of value in throwing additional light upon the nature of

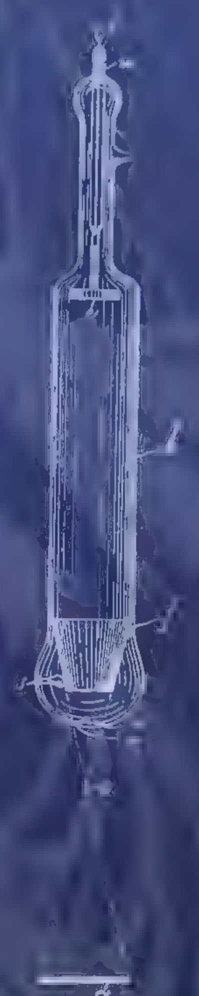


Diagram [illegible]

these radiations, as well as illustrating better properties already known. In the main these observations agree with the views which have forced themselves upon my mind from the outset, namely, that the rays [illegible] of streams of minute material particles projected with great velocity. In numerous experiments I have found that the matter which, by impact within the bulb, causes the formation of the rays, may come from either of the electrodes. Inasmuch as the latter are by continued use disintegrated to a marked degree, it seems more plausible to assume that the projected matter consists of parts of the elec[illegible] rather than of the [illegible]. However, other [illegible] can not [illegible] this con[illegible]. The lumps of projected [illegible] by impact further dis[illegible] particles so minute [illegible] through the walls [illegible] they tear off such particles from the walls, or generally bodies, against which they are projected. At any rate, an impact and consequent shattering seems absolutely necessary for the production of Roentgen rays. The vibration, if there be any, [illegible] that which [illegible] impressed [illegible] vibrations [illegible] longitudinal.

The principal source of the rays [illegible] the place of first impact [illegible] whether it be the [illegible] inclosed insulated body [illegible] wall. When the matter thrown off from an electrode, after striking against an obstacle, is thrown against another body, as the wall of the bulb, for instance, the place of second impact is a very feeble source of the rays.

These and other facts will be better appreciated by referring to the annexed figure, in which a form of tube is shown used in a number of my experiments. The general form is that described on previous occasions. A single electrode e, consisting of a massive aluminium plate, is mounted on a conductor c, provided with a glass wrapping w as usual, and sealed in one of the ends of a straight tube b, about five centimetres in diameter and 30 centimetres long. The other end of the tube is blown out into a thin bulb of a slightly larger diameter, [illegible]

glass stem s a funnel f of thin platinum sheet. In such bulbs I have used a number of different metals for impact with a view of increasing the intensity of the rays and also for the purpose of reflecting and concentrating them. Since, however, in a later contribution, Professor Roentgen has pointed out that platinum gives the most intense rays, I have used chiefly this metal, finding a marked increase in the effect upon the screen or sensitive plate. The particular object of the presently described construction was to ascertain whether the rays generated at the inner surface of the platinum funnel f would be brought to a focus outside of the bulb, and further, whether they would proceed in straight lines from that point. For this purpose the apex of the platinum cone was arranged to be about two centimetres outside of the bulb at o.

When the bulb was properly exhausted and set in action, the glass wall below the funnel f became strongly phosphorescent, but not uniformly, as there was a narrow ring r r on the periphery brighter than the rest, this ring being evidently due to the rays reflected from the platinum sheet.

Placing a fluorescent screen in contact or quite close to the glass wall below the funnel, the portion of the screen in the immediate neighborhood of the phosphorescent patch was brightly illuminated, the outlines being entirely indistinct. Receding now with the screen from the bulb, the strongly illuminated spot became smaller and the outlines sharper, until, when the point o was reached, the luminous part had dwindled down to a small point. Moving the screen a few millimetres beyond o caused a small dark spot to appear, which widened into a circle and became larger and larger in the same measure as the distance from the bulb was increased (see 8), until, at a sufficiently large distance, the dark circle covered the entire screen. This experiment illustrated in a beautiful way the propagation in straight lines which Roentgen originally proved by pinhole photographs. But, besides this, an important point was noted; namely, that the fluorescent glass wall emitted practically no rays, whereas had the platinum not been present, it would have been under similar

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Bridging Bell" Patent.

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DIAGRAM ILLUSTRATING TESLA'S EXPERIMENT.

the electrodes. Inasmuc ter are by continued use d to a marked degree, it plausible to assume that t matter consists of parts trodes themselves rather residual gas. However servations, upon which dwell at present, lead clusion. The lumps o matter are by impact f tegrated into particles to be able to pass throu of the bulb, or else they particles from the walls, bodies, against which t jected. At any rate, an consequent shattering lutely necessary for th of Roentgen rays. The there be any, is only t impressed by the appara vibrations can only be

The principal source o invariably the place of within the bulb, whethe anode, as in some forms o inclosed insulated body, wall. When the matte from an electrode, a against an obstacle, is th another body, as the wal for instance, the place o pact is a very feeble s rays.

These and other facts appreciated by referrin nexed figure, in which a is shown used in a numb periments. The general described on previous o single electrode *e*, con massive aluminium plat on a conductor *c*, prov glass wrapping *w* as usu in one of the ends of a

ROENTGEN RAYS

In our present issue we publish another important communication from Mr. Tesla in regard to the Roentgen rays. Mr. Tesla has worked ceaselessly, and in his articles, exclusively published in our columns, he has made most valuable contributions to the knowledge of this fascinating [illegible]. His opinions carry the greater weight as they are supported by a mass of experimental evidence, and as his ins[illegible] phenomena has proved to be true. What services has he not rendered to science and industry merely by his demonstrations of the action of air or gases in condensers and high-tension transformers! His present contribution is, in part, a summing up of the observations already made by him, and is particularly important [illegible] substantiates the ideas originally expressed by Professor Roentgen.

Mr. Tesla brings forward many convincing arguments to show that these rays consist of streams of matter in some primary condition, which [illegible] to a certain extent, equ[illegible] saying that they are streams of ether into which the matter is di[illegible] the violent impa[illegible]

There is thus opened up a wonderful possibility of transformation of matter into its primary constituents, never before contemplated or thought possible, and it is safe to say that a more absorbing subject for study and investigation could not be found in physical science.

[illegible]TOP CUTTING PRIC[illegible]

[illegible] incandescent lamp manufact[illegible] after two or three years of [illegible]tting of prices, have concluded that [illegible] would be better to maintain a regu-

[illegible] ON [illegible]

[illegible] effects of X rays [illegible]. One of the [illegible] form of a [illegible] persons who [illegible] paratus for [illegible] at a time [illegible] Columbia College [illegible] of New Yo[illegible] each day [illegible] around his [illegible] three hours [illegible] four days [illegible] active work [illegible] effects of t[illegible]. The first [illegible] was a dryi[illegible] paid no att[illegible] became so [illegible] stop all o[illegible] to swell and [illegible] of having [illegible] the end of [illegible] came off [illegible] other effe[illegible] growth of t[illegible] and the ha[illegible] exposed to [illegible] especially o[illegible] head. The [illegible] entirely di[illegible] fact of Mr. [illegible] head [illegible] face and [illegible] fail [illegible] obtain[illegible] each time [illegible] work for t[illegible] one of part[illegible] X rays, Mr. [illegible] his hand [illegible] putting a [illegible] at once [illegible] affording [illegible] The hand

ROENTGEN RAYS ...

(Concluded ...)

... them as ...
... The ... the ...
... comparing ...
... ent bulbs.

V.—ACTION ...

... on which I have ...
will, if verified by ot...
leave no room for ...
radiations are stream...
or possibly of other ...

VII.—THE ENTIRE ... FRACT...

and other features ...
light waves has since Roentgen's
announcement not yet been satis-
factorily explained. A trace at least
of such an effect would be found if
the rays were transverse vibrations.

VIII.—THE DISCHARGE OF CONDUCTORS

by the rays shows, in so far as I have
been able to follow the researches of
others, that the electrical charge ...
taken off by the bodily carriers. It ...
also found that the opacity plays an
important part, and the observations
are mostly ... accord with the ...
view.

IX.—THE SOURCE OF THE RAYS

is, I find, always the place of the first
impact of the cathodic stream, a sec-
ond impact producing little or no ...

... sumed to exist.

X.—SHADOWS ...

An almo... ence of ma... the formation of shadows in ...

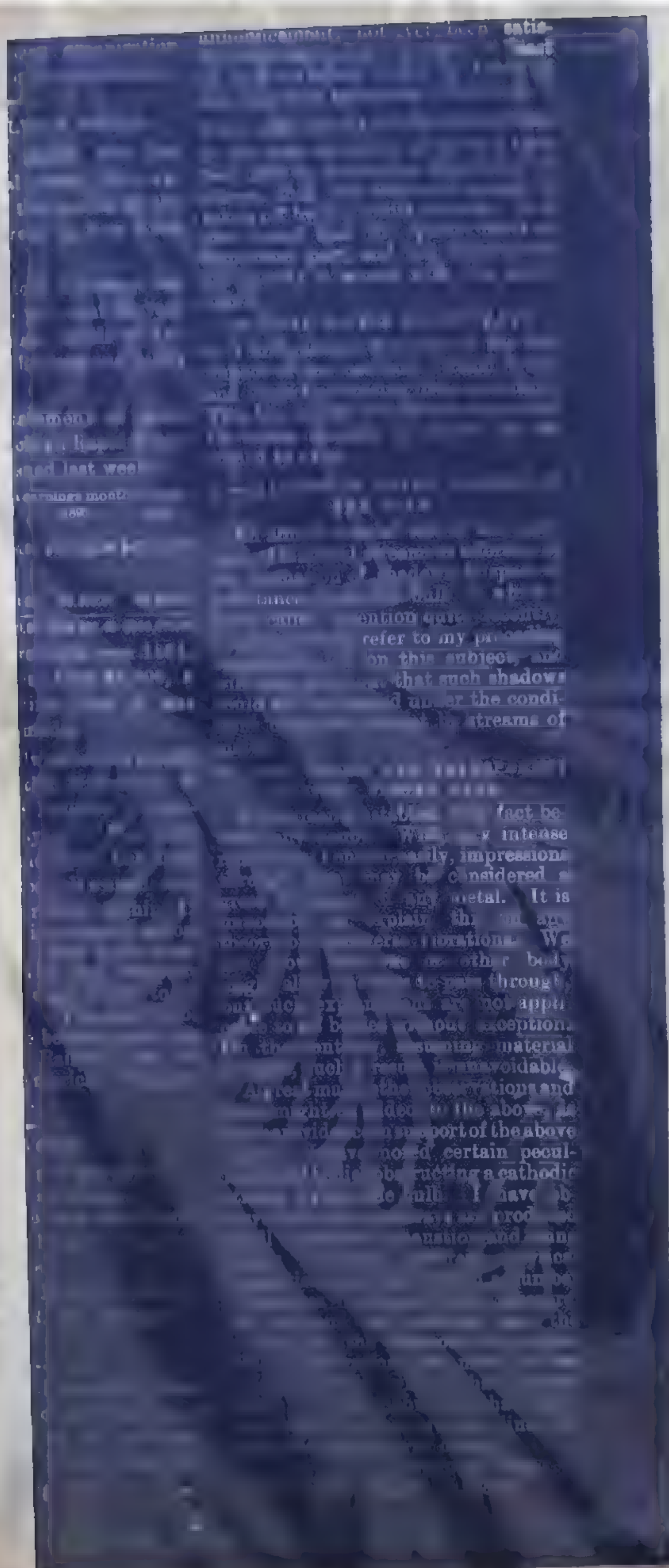
... consisting
...oklyn; Brennan
... Foley, of Jersey
... and arrange the
... the convention.

...WAY NOTES.

... motor ...
... times with ...
... the tracks of the
... road in New York

... bonds of the
... Railway and Light

... than $3,000. ...
... that it was



refer to my pr
on this subject, and
that such shadows
under the condi-
streams of
fact be-
intense
impressions
considered
metal. It is
noted certain pecul-
obstructing a cathodic

[illegible] in free air, even without [illegible] employment of a vacuum bulb, simply by the use of very high potentials, suitable for imparting to the molecules of the air or other particles a sufficiently high velocity. In reality, such puffs or jets of particles are formed in the vicini[illegible] charged [illegible], which is [illegible] shown [illegible] they [illegible] high-poten[illegible] how thi[illegible] rende[illegible] mate[illegible] electro-ma[illegible] by the [illegible] mode of [illegible] in a sta[illegible] and [illegible] which the p[illegible] the frequ[illegible]

It is [illegible] and other [illegible], Roentgen [illegible] inclined to [illegible] rays he [illegible] waves of ether.

After a long and careful [illegible]tion, with apparatus excellently suited for the purpose, capable of producing impressions at great distances, and after examining the results pointed out by other experimenters, I have come to the conclusion which I have already intimated in my former contributions to your esteemed journal, and which I now find courage to pronounce without hesitation, that the original hypothesis of Roentgen will be confirmed in two particulars: first, in regard to the longitudinal character of the disturbances; second, in regard to the medium concerned in their propagation. The present expression of my views is made solely for the purpose of preserving a faithful record of what, to my mind, appears to be the true interpretation of these new and important manifestations of energy.

Recent observations of some dark radiations from novel sources by Becquerel and others, and certain deductions of Helmholtz, seemingly applicable to the explanation of [illegible] peculiarities of the Roentgen rays, have given additional weight to the arguments on behalf of the theory [illegible] tube. The exit from the latter is, however, the more likely to occur, as the lumps of matter must be shattered into still much smaller particles by the impact. From my experiments on reflection of the Roentgen rays, before reported, which, with powerful radiations, may be shown to exist under all angles of incidence, it appears that the lumps or molecules are indeed shattered into fragments or constituents so small as to make them lose [illegible] physical properties possessed before the impact. Thus, the material composing the electrode, the [illegible] the bulb or [illegible]traction of any [illegible] placed within the latter, are of [illegible] no consequence, except in [illegible] the intensity of the radiation [illegible] concerned. It also appears, as I have pointed out, that no further disintegration of the lumps is attendant upon a second impact. The matter composing the cathodic stream is, to all evidence, reduced to matter of [illegible] primary form, heretofore not [illegible] as such velocities and such [illegible] impacts have probably never been studied or even attained before these extraordinary manifestations were observed. Is it not possible that the very [illegible] vortexes which, according to Lord Kelvin's ideal theory, compose the lumps, are dissolved, and that in the Roentgen phenomena we may witness a transformation of ordinary matter into ether? It is in this sense that, I think, Roentgen's first hypothesis will be confirmed. In such case there can be, of course, no question of waves other than the longitudinal assumed by him, only, in my opinion, the frequency must be very small—that of the electro-magnetic vibrating system—generally not more than a few millions a second. If such process of transformation does take place, it will be difficult, if not impossible, to determine the amount of energy represented in the radiations, and the statement that this amount is very small should be received with some caution.

As to the rays exhaustively studied by Lennard, which have proved to be the nucleus of these great realisations, I hold them to be true cathodic streams, projected through the wall of [illegible]

Upon the disappearance of the first fluorescence the rarefaction increases slowly, this being a necessary result of particles being projected from the electrode and fastening themselves upon the wall. These particles absorb a large portion of the residual gas. The latter can be again freed by the application of heat to the bulb or otherwise. So much of the effects observed by these investigators. In the instance observed by myself, there must be actual expulsion of matter, and for this speak following facts: (a) the exhaustion is quicker when the glass is thin; (b) when the potential is higher; (c) when the discharges are more sudden; (d) when there is no obstruction within the bulb; (e) the exhaustion takes place quickest with an aluminum or platinum electrode, the former metal giving particles moving with greatest velocity, the latter particles of greatest weight; (f) the glass wall, when softened by the heat, does not collapse, but bulges outwardly; (g) the exhaustion takes place, in some cases, even if a small perceptible hole is pierced through the glass; (h) all causes tending to impart a greater velocity to the particles hasten the process of exhaustion.

[illegible] RELATION BETWEEN OPACITY AND DENSITY.

The important fact pointed out early by Roentgen and confirmed by subsequent research, namely, that a body is the more opaque to the rays the denser it is, can not be explained as satisfactorily under any other assumption as that of the rays being streams of matter, in which case such simple relation between opacity and density would necessarily exist. This relation is the more important in its bearing upon the nature of the rays, as it does not at all exist in light-giving vibrations, and should consequently not be found to so marked a degree and under *all conditions with vibrations*, presumably similar to and approximating in frequency the light vibrations.

III—DEFINITION OF SHADOWS ON SCREEN OR PLATE.

When taking impressions or observ[illegible] bones grows deeper, and in this [illegible]borhood a place can be found af[illegible] the definition of the shadow is [illegible]est. If the distance is still further continually increased, the detail is lost, and finally only a vague shadow is perceptible, showing apparently the outlines of the hand.

This often-noted fact disagrees entirely with any theory of transverse vibrations, but can be easily explained on the assumption of material streams. When the hand is near and the velocity of the stream of particles very great, both bone and flesh are easily penetrated, and the effect due to the difference in the retardation of the particles passing through the heterogeneous parts can not be observed. The screen can fluoresce only up to a certain limited intensity, and the film can be affected only to a certain small degree. When the distance is increased, or, what is equivalent, when the intensity of the radiation is reduced, the more resisting bones begin to throw the shadow first. Upon a further increase of the distance the flesh begins likewise to stop enough of the particles to leave a trace on the screen. But in all cases, at a certain distance, manifestly that which under the conditions of the experiment gives the greatest difference in the trajectories of the particles within *the range perceptible on the screen or film*, the clearest shadow is secured.

IV—THE RAYS ARE ALL OF ONE KIND.

The preceding explains the apparent existence of rays of different kinds, that is, of different rates of vibration, as it is asserted. In my opinion, the velocity and possibly the size of the particles both are different, and this fully accounts for the discordant results obtained in regard to the transparency of various bodies to these rays. I found, for example, in many cases that aluminum was less transparent than glass, and in some instances brass appeared to be very transparent as compared with other metallic bodies. Such observations showed that it was necessary, in making the comparison, to take rigorous[illegible] equal thicknesses of the bodi[illegible]

(Concluded on page [illegible].)

On Roentgen Rays or Streams.

To the Editor of the Electrical Review:

In the original report of his epochal ... Roentgen ...

[illegible]

... ught to notice the ... ar material streams ... subsequently, upon ... ncement, found ...

... of very high ... imparting to ... or other particles ... ity. In reality, such pa... or je... of particles are formed in the vicinity of every highly charged conductor, the potential of which is rapidly varying, and I have shown that, unless they are prevented, they are fatal to every condenser or ... transformer, no matter ... the insulation. They also ...

of transverse vibrations, and accordingly this interpretation of the phenomena is held in favor. But this view is still of a purely speculative character, being, as it is at present, ...

[illegible]

... cable to a cathod... presently so much familiarized myself with this view that, if I had no experimental evidence, I would not question the fact that some matter is projected through the thin wall of a vacuum ... The exit from the latter is, however, the more likely to occur, as the lumps of matter must be shattered into still much smaller ... the impact. From my ex... as reflection of the Roentgen ... fore reported, which, with ... radiations, may be shown ... under all ... that the ... are indeed shattered ... ends so ... entirely ... ssed before ... material composing the electrode, the ...

the tube. Their deflectibility by a ... magnet shows to my mind simply that they differ but little from those within the bulb. The lumps of matter are probably large and the velocity small as compared with that of the ... would, how...

[illegible]

... high degree ... organic matter ...

[illegible]

... by the applic... or otherwise ... observed by these investi... the instance observed by ... must be actual expulsion ... and for this speck follow... (a) the exhaustion is ... then ... both ... are easily

... ing shadows while ... intensity of the radiations, ... taining all other conditions as nearly as possible alike, it is found that the employment of more intense radiations secures little, if any, advantage as regards the definition of the ...

[illegible] induction coils are suitable, they afford ideal instruments. New applications will no doubt be found, but it is very probable that their chief employment will be for purposes of lighting by high-frequency currents, in which Tesla is the recognized pioneer.

[illegible] the effect [illegible] inventor in describing a few forms of his appliances for high-frequency phenomena:

The object of my present improvements is to provide a simple, compact and effective apparatus for producing these effects, but adapted more particularly for direct application to and use with existing circuits carrying direct currents, such as the ordinary municipal incandescent lighting circuits. The way in which I accomplish this so as to meet the requirements of practical and economical operation under the conditions named will be understood from a general description of the apparatus which I have devised. In any given circuit, which for present purposes may be considered as conveying direct currents or those of substantially the character of direct or continuous currents, and which, for general purposes of illustration, may be assumed to be a branch or derived circuit across the mains from any ordinary source, I interpose a device, or devices, in the nature of a choking coil, in order to give to the circuit a high self-induction. I also provide a circuit controller of any proper character that may be operated to make and break said circuit. Around the break, or point of interruption, I place a condenser, to receive and store the energy of the discharge current, and in a local circuit and in series with such condenser, I place the primary of a transformer, the secondary of which then becomes the source of the currents of high frequency. It will be apparent from a consideration of the conditions involved that, were the condenser to be directly charged by the current from the source, and then discharged [illegible] this latter function may be varied at will to regulate the periods of charging and discharging.

The controller C is designed to be rotated by any proper device, such, for example, as an electro magnetic motor, as shown in Fig. 1, receiving current either from the main source or elsewhere. Around the controller C, or, in general, in parallel therewith, is a condenser H, and in series with the latter the primary K of a transformer, the secondary L of which constitutes the source of the currents of high frequency which may be applied to many useful purposes, as for electric illumination, the operation of Crookes tubes, or the production of high vacua.

L' indicates the circuit from the secondary, which may be regarded as the working circuit.

A more convenient and simplified arrangement of the apparatus is shown in Fig. 2. In this case the small motor G, which drives the controller, has its field coils in derivation to the main circuit, and the controller C and condenser H are in parallel in the field circuit between the two coils. In such case the field coils M take the place of the choking coils B. In this arrangement, and, in fact, generally, it is preferable to use two condensers, or a condenser in two parts, and to arrange the primary coil of the transformer between them. The interruptions of the field current of the motor should be so rapid as to permit only a partial demagnetization of the cores. These latter, however, should in this specific arrangement be laminated.

In a modified arrangement the coils operating the interrupter are placed in series with a coil of large self-induction, or the latter is dispensed with by giving to the coils a suitable self-induction. Quoting the inventor, "this apparatus may be constructed and combined in very compact form and small compass. Its operation involves but a small expenditure of energy, while it requires practically no care or attention for the continued

TESLA'S ELECTRICAL OSCILLATORS.

The important researches and experiments which Nikola Tesla has been carrying on for years, and which have created such a widespread interest in the scientific world, have culminated in the production of thoroughly practical and efficient electrical oscillators or transformers for the conversion of ordinary direct or alternating currents into electrical vibrations of any desired frequency. In five patents, granted to him September 22, 1896, he shows typical forms of his apparatus as adapted to any of the usual sources of supply. The remarkably clear and simple description of the features involved makes it perfectly easy for any one to understand the operation of these most valuable appliances.

The numerous uses to which these high-frequency transformers can be put will, we believe, cause their rapid and extensive introduction, and it is difficult to estimate the benefit which will result to science and industry from their applications. For lighting with phosphorescent bulbs or tubes, for the production of Roentgen phenomena, for the manufacture of ozone, argon and such bodies, for electro-therapeutic employment, and many uses for which induction coils are suitable, they afford ideal instruments. New applications will no doubt be found, but it is very probable that their chief employment will be for purposes of lighting by high-frequency currents, in which Tesla is the recognized pioneer.

We quote the exact language of the ... ribing a few forms of

into the working circuit, a very large capacity would ordinarily be required, but by the above arrangement the current of high electro-motive force, which is induced at each break of the main circuit, furnishes the proper current for charging the condenser, which may, therefore, be small and inexpensive. Moreover, it will be observed that, since the self-induction of the circuit through which the condenser discharges, as well as the capacity of the condenser itself, may be given practically any desired value, the frequency of the discharge current may be adjusted at will.

Fig. 1 is a diagrammatic illustration of the apparatus, and Fig. 2 a modification of the same.

Referring to Fig. 1, A designates any source of direct current. In any branch of the circuit from said source, such, for example, as would be formed by the conductors A′ A′ from the mains A and the conductors K K, are placed self-induction or choking coils B B and a circuit controller C. This latter may be an ordinary metallic disk or cylinder with teeth or separated segments D D, E E, of which one or more pairs, as E E, diametrically opposite, are integral or in electrical contact with the body of the cylinder, so that when the controller is in the position in which the two brushes F F bear upon two of said segments E E, the circuit through the choking coils B will be closed. The segments D D are insulated, and while shown in the drawings as of substantially the same length of arc as the segments E E, this latter relation may be varied at will to regulate the periods of charging and discharging.

The controller C is designed to be rotated by any proper device, such, for example, as an electro-magnetic motor, as shown in Fig. 2, receiving current either from the main source or elsewhere. Around the controller C, or, in general, in parallel therewith, is a condenser H, and in series with the latter the primary K of a transformer,

production of ozone in unlimited amount.

Dwelling specifically upon the conversion of alternating or undulating currents, Mr. Te[illegible]

When the potential of the source periodically rises and falls, whether [illegible] reverses or not is immaterial [illegible] essential to economical operation [illegible] the intervals of interruption of the [illegible] should bear [illegible] to the period of the [illegible]

[illegible]

[illegible] ing of equivalent [illegible] force be employed.

[illegible]

circuit of [illegible] self-induction, one terminal of which is connected directly to a condenser terminal and the other to the brush H opposite to that connected with the other condenser terminal, so that the discharge circuit of the condenser will be completed simultaneously with the motor circuit and interrupted while the motor circuit is broken and the condenser being charged.

The discharge circuit contains a primary M of a few turns, and this induces in a secondary N impulses of high potential, which, by reason of their great frequency, are available for the operation of vacuum tubes [illegible] terminal lamps [illegible] vel and useful purposes.

It is obvious that the supply current need not be alternating, provided it be converted or transformed into

FIG. [illegible] —DIAGRAM ILLUSTRATING CONNECTIONS OF OSCILLATOR AS ADAPTED TO AN [illegible] CUIT.

an alternating current before reaching [illegible]

With such arrangement it is evident that any two adjacent segments $c\ c$ become the terminals of an alternating current source, so that if two brushes H H be applied to the periphery of the cylinder, they will take off current during such portion of the wave as the width of segment and position of the brushes may determine. By adjusting the position of the brushes relatively to the cylinder, therefore, the alternating current delivered to the segments $c\ c$ may be interrupted at any point in its waves.

While the brushes H H are on the conducting segments, the current which they collect stores energy in a circuit of high self-induction formed

FIG. [illegible] TESLA'S [illegible] OSCILLATOR —DRAWING ILLUSTRATING A SIMPLIFIED FORM OF OSCILLATOR AND CONNECTIONS.

by the wires $f\ f$, self-induction coils S S, the conductors B B, the brushes and commutator. [illegible]

[illegible] its own [illegible] of vibration [illegible] alternately [illegible] a given circuit [illegible] periodic impulses [illegible] and to discharge it [illegible] the frequency of the impressed impulses should bear a definite [illegible] to the frequency of vibration possessed by the circuit itself. Moreover, for like reasons the period of vibration of the discharge [illegible] should bear a similar relation [illegible] impressed impulses of the [illegible] the charging circuit. When the conditions are such that the [illegible] of harmonic vibrations is fo[illegible] circuits are said to be in [illegible] or in electro-magnetic synchronism, and this condition I have [illegible] in my system to be highly advantageous. Hence in practice [illegible] the electrical constants [illegible] circuits so that in [illegible] this condition [illegible] approximately attained [illegible] with this [illegible]

[illegible]

[illegible] more of these [illegible] a variation in its period. [illegible] are, therefore, various [illegible] which the frequencies of [illegible] tion of the several [illegible] the system referred to may be [illegible]

sla says:

tential of the source es and falls, whether r not is immaterial, it e [illegible] operation s of [illegible] of the should bear a definite the period of the current that the effective impulses charging the be as high as possible [illegible] in case an [illegible] electro-motive [illegible] the source of [illegible] which will charging circuit at ermined with reference ns of potential therein. [illegible] for ac- [illegible] I am aware, [illegible]

[illegible]

by the primary C and D. The circuit of the includes the energizing ynchronous motor E and a ntroller, which, in the stance, in Fig. 3, is shown ed of a metal disk F with egments F in its periphery

denser terminal, so that the circuit of the condenser will be completed simultaneously with the motor circuit and interrupted while the motor circuit is broken and the condenser being charged.

The discharge circuit contains a primary M of a few turns, and this induces in a secondary N impulses of high potential, which, by reason of their great frequency, are available for the operation of vacuum tubes P, single terminal lamps R, and other novel and useful purposes.

It is obvious that the supply current need not be alternating, provided it be converted or transformed into

FIG. 1.—TESLA'S ELECTRICAL OSCILLATOR —DIAGRAM ILLUSTRATING CONNECTIONS OF OSCILLATOR AS ADAPTED TO AN ORDINARY [illegible] LIGHTING CIRCUIT.

an alternating current before reach-

take off current during the of the wave as the width of and position of the bru determine. By adjusting th of the brushes relatively to der, therefore, the alterna rent delivered to the seg may be interrupted at an its waves.

While the brushes H H conducting segments, th which they collect stores circuit of high self-induct

FIG. 2.—TESLA'S ELECTRIC —DRAWING ILLUSTRATIN FORM OF OSCILLATOR AN

by the wires $f f$, self-in S S, the conductors B B and commutator. Whe

interrupted while the
it is broken and the con-
g [illegible]
[illegible] circuit [illegible] a
[illegible] and this
[illegible] secondary K impulses of
[illegible] which, by reason of
[illegible] are available for
[illegible] tubes T,
[illegible] lamps [illegible] and other
[illegible] purposes.
[illegible] that the supply cur-
[illegible] be alternating, provided
[illegible] transformed into

[T]esla's Electrical Oscillator
[Diagr]am Illustrating Connections
[Osc]illator as Adapted to an
[illegible] Municipal Lighting Cir-

[altern]ating current before reach-

[illegible] determine. By adjusting the position
of the brushes relatively to the cylin-
der, therefore, the alternating cur-
rent delivered to the segments [illegible]
may be interrupted at any point in
its waves.

While the brushes H H are on the
conducting segments, the current
which they collect stores energy in a
circuit of high self-induction formed

Fig. [illegible]—Tesla's Electrical Oscillator
—Drawing Illustrating a Simplified
Form of Oscillator and Connections.

by the wires f f, self-induction coils
[illegible], the conductors [illegible], the brushes
and commutator. When this circuit

the frequency [illegible]
pulses should be[ar]
to the frequenc[y]
essed by the [illegible]
over, for like r[illegible]
vibration of th[e]
should bear a [illegible]
impressed impu[lses]
the charging ci[rcuit]
ditions are such
of harmonic vib[ration]
circuits are sa[illegible]
or in electro-m[illegible]
and this con[illegible]
in my system [illegible]
tageous. Hen[ce]
the electrical [illegible]
cuits so that [illegible]
this conditio[n]
approximately [illegible]
plish this, the
current direc[illegible]
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the period o[f]
[illegible]
or more of
a variation [illegible]
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which the [illegible]
tion of th[e]
the system r[illegible]
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ssential to economical operation
. the intervals of interruption . . .
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. . . order that the effective
. . . of the impulses charging the
denser may be as high as possible.

. . . essed by the primary . . .
. . . ndary D. The circuit of the
. . . ndary includes the energizing
. of a synchronous motor E and a
. . . controller, which, in the
. . . at instance, in Fig. 3, is shown
. . . mposed of a metal disk F with
. . . ated segments F' in its periphery

motor circuit is broken and the condenser being charged.

The . . . circuit . . . a primary M of a few turns, and this induces in a secondary N impulses of high potential, which, by reason of . . . great frequency, are available for the operation of vacuum tubes P, single terminal lamps R and other novel and useful purposes.

It is obvious that the supply current need not be alternating, provided it be converted or transformed into

Fig. 1.—Tesla's Electrical Oscillator —Diagram Illustrating Connections of Oscillator as Adapted to an Ordinary . . . Circuit.

an alternating current before reach-

. . . By adjusting the position of the brushes relatively to the cylinder, therefore, the alternating current delivered to the segments c c may be interrupted at any point in its waves.

While the brushes H H are on the conducting segments, the current which they collect . . . energy to a circuit of high self-induction formed

Fig. 2.—Tesla's . . . —Drawing Illustrating a Simplified Form of Oscillator and Connect . . .

by the wires f f, self-induction coils S S, the conductors B B, the brushes and commutator. When this circuit

. . . to discharge it . . .
the frequency of the im . . .
pulses should bear a definite . . .
to the frequency of vibratio . . .
sessed by the circuit itself . . .
over, for like reasons the . . .
vibration of the discharg . . .
should bear a similar rela . . .
impressed impulses or the . . .
the charging circuit. When . . .
ditions are such that the . . .
of harmonic vibrations is . . .
circuits are said to be in . . .
or in electro-magnetic sy . . .
and this condition I have . . .
in my system to be highly . . .
tageous. Hence in practice . . .
the electrical . . .
cuits so that in normal . . .
the conditions of . . .
approximately attained. To
. . .
. . . capacity, a variation of . . .
or more of these may . . .
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ace, therefore, various . . .
which the frequencies . . .
tion of the several cir . . .
the system referred to may . . .
but the most practicable . . .

[illegible] circuits, a branch circuit [illegible] off from the mains, and, in [illegible] raise the potential of the [illegible] a transformer is employed represented by the primary C and secondary D. The circuit of the secondary includes the energizing coils of a synchronous motor E and a circuit controller, which, in the present instance, in Fig. 3, is shown as composed of a metal disk F with insulated segments F' in its periphery and fixed to the shaft of the motor. An insulating arm G, stationary with respect to the motor shaft and adjustable with reference to the poles of the fixed magnets, carries two brushes H H which bear upon the periphery of the disk. With the parts thus arranged, the secondary circuit is completed through the coils of the motor whenever the two brushes rest [illegible] segments of the [illegible] through the motor at other times. Such a motor, if properly [illegible] is well understood [illegible] chronism [illegible]

[illegible]

[illegible] H [illegible] adjacent [illegible] through the motor is interrupted, the terminals of the motor circuit will be connected with the condenser, whereby the latter will receive the high-potential inductive discharge from the motor or secondary circuit.

The condenser discharges into a [illegible]

FIG. 1.—TESLA'S ELECTRICAL OSCILLATOR—DIAGRAM ILLUSTRATING CONNECTIONS OF OSCILLATOR AS ADAPTED TO AN ORDINARY MUNICIPAL LIGHTING CIRCUIT.

an alternating current before reaching the controller. For example, the present improvements are applicable to various forms of rotary transformers, as is illustrated in Fig. 4.

[illegible] designate [illegible] current [illegible]

FIG. [illegible]—TESLA'S ELECTRICAL OSCILLATOR [illegible] CONNEC[illegible] MUNICIPAL ALTE[illegible]

[illegible]

[illegible] connected in p[illegible] in Fig. 4.

Through the shaft run two insulated conductors e e from any two commutator segments 90 degrees apart, and these connect with the two pairs of segments c, respectively.

FIG. 2.—TESLA'S ELECTRICAL OSCILLATOR—DRAWING ILLUSTRATING A SIMPLIFIED FORM OF OSCILLATOR AND CONNECTIONS.

by the wires f f, self-induction coils S S, the conductors B B, the brushes and commutator. When this circuit is interrupted by the brushes H H passing on to the insulating segments of the controller, the high-potential discharge of this circuit charges the condensers K K, which then dis-[illegible]

FIG. [illegible]—TESLA'S ELECTRICAL OSCILLATOR—DIAGRAM [illegible] APPARATUS AND CONNECTIONS AS ADAPTED TO SOME OF ROTATING TRANSFORMER OPERATED FROM [illegible] LIGHTING CIRCUIT.

[illegible] the circuit of low [illegible] containing the primary [illegible] circuit N contains [illegible]

[illegible] are shown mounted on the [illegible] and a transformer is employed in connection to raise the tension of the supply current.

In regard to the regulation of his system Tesla says:

It is well known that every electric circuit, provided its ohmic resistance [illegible]

[illegible] of the several [illegible] system referred to [illegible] but the most practical ways of accomplishing [illegible] result are the following: [illegible] ing the rate of the impulses of current, or those which [illegible] rected from the source [illegible]

[illegible] charging circuit, as by varying the speed of the commutator or other circuit controller; (b) varying the self-induction of the charging circuit; (c) varying the self-induction [illegible] capacity of the discharge circuit.

To regulate the output of a single circuit which has no vibration of its own by merely varying its period would evidently require, for any extended range of regulation, a very wide range of variation of period; but in the system described, a very wide range of regulation of the output may be obtained by a very slight change of the frequency of one of the circuits when the above-mentioned rules are observed.

[illegible]n alternating current before reaching the controller. For example, the [illegible]resent improvements are applicable to various forms of rotary transformers, as is illustrated in Fig. 4.

[illegible] designates a continuous-[illegible]

S S, the conductors B B, the brushes and commutator. When this circuit is interrupted by the brushes H H passing on to the insulating segments of the controller, the high-potential discharge of this circuit charges the condensers K K, which then dis-

the system referred to [illegible] but the most practicable [illegible] ways of accomplishing [illegible] result are the following [illegible] ing the rate of the impress[illegible] of current, or those which [illegible] rected from the source of [illegible]

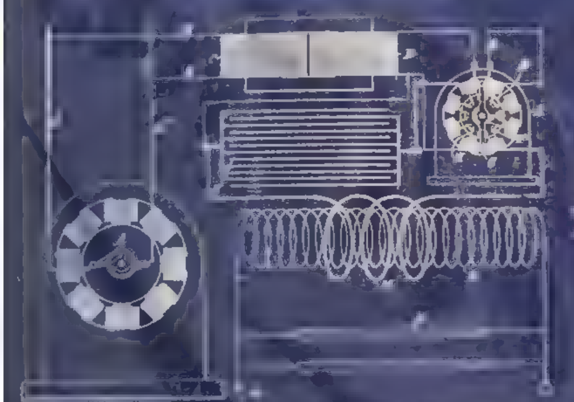


Fig. 3.—Tesla's Electrical Oscillator—Diagram Illustrating Apparatus and Connections as Adapted to a [illegible]

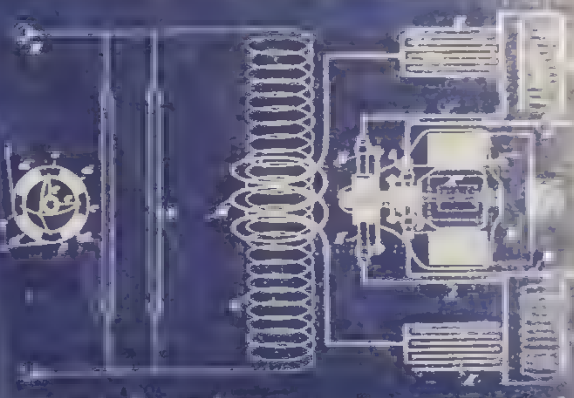


Fig. 4.—Tesla's Electrical Oscillator—Diagram Illustrating Apparatus and Connections as Adapted to Form of Rotating Transformer Operated from [illegible]

[illegible]

[illegible]nected in pairs, as shown in detail

[illegible]e through the circuit of low self-[illegible] containing the primary M. The secondary circuit N contains any [illegible] for utilizing the current.

In other ar[illegible] circuit controllers of special construction are shown mounted on the shaft of a generator, and a transformer is employed in connection to raise the ten-

[illegible] the speed of the commutator or other circuit controller; (b) varying the self-induction of the charging circuit; (c) varying the self-induction or capacity of the discharge circuit.

To regulate the output of a single circuit which has no vibration of its own, by merely varying its period, would evidently require, for any extended range of regulation, a wide range of variation of period;

TESLA ON ELECTRICITY.

HIS ADDRESS IN FULL ON THE OCCASION OF THE COMMEMORATION OF THE INTRODUCTION OF NIAGARA FALLS POWER IN BUFFALO AT THE ELLICOTT CLUB, JANUARY 12, 1897.

I have scarcely had courage enough to address an audience on a few unavoidable occasions, and the experience of this evening, even as disconnected from the cause of our meeting, is quite novel to me. Although in those few instances, of which I have retained agreeable memory, my words have met with a generous reception, I never deceived myself, and knew quite well that my success was not due to any excellency in the rhetorical or demonstrative art. Nevertheless, my sense of duty to respond to the request with which I was honored a few days ago was strong enough to overcome my very grave apprehensions in regard to my ability of doing justice to the topic assigned to me. It is true, at times—even now, as I speak—my mind feels full of the subject, but I know that, as soon as I shall attempt expression, the fugitive conceptions will vanish, and I shall experience certain well known sensations of abandonment, chill and silence. I can see already your disappointed countenances and can read in them the painful regret of the mistake in your choice.

These remarks, gentlemen, are not made with the selfish desire of winning your kindness and indulgence on my shortcomings, but with the honest intention of offering you an apology for your disappointment. Nor are they made—as you might be disposed to think—in that playful spirit which, to the enjoyment of the listeners, is often displayed by belated speakers. On the contrary, I am deeply earnest in my wish that I were capable of having the fire of eloquence kindled in me, that I might dwell in adequate terms on this fascinating science of electricity, on the marvelous development which electrical annals have recorded and which, as one of the speakers justly remarked, stamp this age as the Electrical Age, and particularly on the great event we are commemorating this day. Unfortunately, this my desire must remain unfulfilled, but I am hopeful that in my formless and incomplete statements, among the few ideas and facts I shall mention there may be something of interest and usefulness, something befitting this welcome occasion.

ence with the fundamental law of motion, which commands acceleration and increase of momentum or accumulation of energy under the action of a continuously acting force and tendency, and is the more true as every advance weakens the elements tending to produce friction and retardation. For, after all, what is progress, or—more correctly—development, or evolution, if not a movement, infinitely complex and often unscrutinizable, it is true, but nevertheless exactly determined in quantity as well as in quality of motion by the physical conditions and laws governing? This feature of more recent development is best shown in the rapid merging together of the various arts and sciences by the obliteration of the hard and fast lines of separation, of borders, some of which only a few years ago seemed unsurpassable, and which, like veritable Chinese walls, surrounded every department of inquiry and barred progress. A sense of connectedness of the various apparently widely different forces and phenomena we observe is taking possession of our minds, a sense of deeper understanding of nature as a whole, which, though not yet quite clear and defined, is keen enough to inspire us with the confidence of great realizations in the near future.

But these features chiefly interest the scientific man, the thinker and reasoner. There is another feature which affords us still more satisfaction and enjoyment, and which is of still more universal interest, chiefly because of its bearing upon the welfare of mankind. Gentlemen, there is an influence which is getting strong and stronger day by day, which shows itself more and more in all departments of human activity, an influence most fruitful and beneficial—the influence of the artist. It was a happy day for the mass of humanity when the artist felt the desire of becoming a physician, an electrician, an engineer or mechanician or—whatnot—a mathematician or a financier; for it was he who wrought all these wonders and grandeur we are witnessing. It was he who abolished that small, pedantic, narrow-grooved school teaching which made of an aspiring student a galley-slave, and he who allowed freedom in the choice of subject of study according to one's pleasure and inclination, and so facilitated development.

Some, who delight in the exercise of their powers of criticism, call this an unsymmetrical development, a degeneration or departure from the normal, or even a degradation of the race. But they are mistaken. This is a welcome state of things, a blessing, a wise subdivision of labors, the establishment of conditions most favorable to progress. Let one concentrate all his energies in one single great effort, let him perceive a single truth, even though he be consumed by the sacred fire, then millions of less gifted men can easily follow. Therefore it is not as much quantity as quality of work

they are going to pounce upon each other at a given signal and destroy themselves; that they are all trying to outdo that victorious, great, wonderful German army, against which there is no resistance, for every German has the discipline in his very blood—every German is a soldier. But these men are in error. Look only at our recent experience with the British in that Venezuela difficulty. Two other nations might have crashed together, but not the Anglo-Saxons; they are too far ahead. The men who tell you this are ignoring forces which are continually at work, silently but resistlessly—forces which say Peace!

There is the genuine artist, who inspires us with higher and nobler sentiments, and makes us abhor strife and carnage. There is the engineer, who bridges gulfs and chasms, and facilitates contact and equalization of the heterogeneous masses of humanity. There is the mechanic, who comes with his beautiful time and energy-saving appliances, who perfects his flying machine, not to drop a bag of dynamite on a city or vessel, but to facilitate transport and travel. There, again, is the chemist, who opens new resources and makes existence more pleasant and secure; and there is the electrician, who sends his messages of peace to all parts of the globe. The time will not be long in coming when those men who are turning their ingenuity to inventing quick-firing guns, torpedoes and other implements of destruction—all the while assuring you that it is for the love and good of humanity—will find no takers for their odious tools, and will realize that, had they used their inventive talent in other directions, they might have reaped a far better reward than the sestertia received. And then, and none too soon, the cry will be echoed everywhere, Brethren, stop these highhanded methods of the strong, these remnants of barbarism so inimical to progress! Give that valiant warrior opportunities for displaying a more commendable courage than that he shows when, intoxicated with victory, he rushes to the destruction of his fellow-men. Let him toil day and night with a small chance of achieving and yet be unflinching; let him challenge the dangers of exploring the heights of the air and the depths of the sea; let him brave the dread of the plague, the heat of the tropic desert and the ice of the polar region. Turn your energies to warding off the common enemies and dangers, the germs that are all around you, that threaten you in the air you breathe, in the water you drink, in the food you consume. Is it not strange, is it not shame, that we, beings in the highest state of development in this our world, beings with such immense powers of thought and action, we, the masters of the globe, should be absolutely at the mercy of our unseen foes, that we should not know whether a swallow of food or drink brings joy and life or pain and destruction to us! In this

broad one of converting the greatest possible amount of heat energy into mechanical power, but it was rather the specific problem of obtaining the mechanical power in such form as to be best suitable for general use. As the reciprocating motion of the piston was not convenient for practical purposes, except in very few instances, the piston was connected to a crank, and thus rotating motion was obtained, which was more suitable and preferable, though it involved numerous disadvantages incident to the crude and wasteful means employed. But until quite recently there were at the disposal of the engineer, for the transformation and transmission of the motion of the piston, no better means than rigid mechanical connections. The past few years have brought forcibly to the attention of the builder the electric motor, with its ideal features. Here was a mode of transmitting mechanical motion simpler by far, and also much more economical. Had this mode been perfected earlier, there can be no doubt that, of the many different types of engine, the majority would not exist, for just as soon as an engine was coupled with an electric generator a type was produced capable of almost universal use. From this moment on there was no necessity to endeavor to perfect engines of special designs capable of doing special kinds of work. The engineer's task became now to concentrate all his efforts upon one type, to perfect one kind of engine—the best, the universal, the engine of the immediate future; namely, the one which is best suitable for the generation of electricity. The first efforts in this direction gave a strong impetus to the development of the reciprocating high-speed engine, and also to the turbine, which latter was a type of engine of very limited practical usefulness, but became, to a certain extent, valuable in connection with the electric generator and motor. Still, even the former engine, though improved in many particulars, is not radically changed, and even now has the same objectionable features and limitations. To do away with these as much as possible, a new type of engine is being perfected in which more favorable conditions for economy are maintained, which expands the working fluid with utmost rapidity and loses little heat on the walls, an engine stripped of all usual regulating mechanism—packings, oilers and other appendages—and forming part of an electric generator; and in this type, I may say, I have implicit faith.

The gas or explosive engine has been likewise profoundly affected by the commercial introduction of electric light and power, particularly in quite recent years. The engineer is turning his energies more and more in this direction, being stimulated by the prospect of obtaining a higher thermodynamic efficiency. Much larger engines are now being built, the construction is constantly improved, and a novel type of engine, best suitable for the genera

[illegible] pinnacle of a new advance into some [illegible] region, where at every step [illegible] beckons friendly, and leads the toiler [illegible] to hard and harder tasks.

But among all these many [illegible] of research, these many branches of industry, new and old, which are being rapidly expanded, there is one dominating all others in importance—one which is of the greatest significance for the comfort and welfare, not to say for the existence, of mankind, and that is the electrical transmission of power. [illegible] in this most important of all [illegible]. Long afterwards, when time will have placed the events in their proper perspective, and assigned men to their deserved places, the great event we are commemorating to-day will stand out as designating a new and glorious epoch in the history of humanity—an epoch grander than that marked by the advent of the steam engine. We have many a monument of past ages; we have the palaces and pyramids, the temples of the Greek and the cathedrals of Christendom. In them [illegible] exemplified the power of men, the greatness of nations, the love of art and religious devotion. But that monument at Niagara has something of its own, more in accord with our present thoughts and tendencies. It is a monument worthy of our scientific age, a true monument of enlightenment and of peace. It signifies the subjugation of natural forces to the service of man, the discontinuance of barbarous methods, the relieving of millions from want and suffering. No matter what we attempt to do, no matter to what fields we turn our efforts, we are dependent on power. Our economists may propose more economical systems of administration and [illegible] of resources, our legislators may make wiser laws and treaties, it matters little; that kind of help can be only temporary. If we want to reduce poverty and misery, if we want to give to every deserving individual what is needed for a safe existence of an intelligent being, we want to provide more machinery, more power. Power is our mainstay, the primary source of our many-sided energies. With sufficient power at our disposal we can satisfy most of our wants and offer a guaranty for safe and comfortable existence to all, except perhaps to those who are the greatest criminals of all—the voluntarily idle.

The development and wealth of a city, the success of a nation, the progress of the whole human race, is regulated by the power available. Think of the victorious march of the British [illegible] which history has never [illegible] the qualities of the race which [illegible] been of great moment, they owe the conquest of the world to—coal. For with coal they produce their [illegible] coal [illegible] light and heat, coal drives the wheels of their [illegible] manufacturing establishments and coal propels their conquering fleets. But the stores are being more and more exhausted, the labor is getting dearer and dearer, and the demand is constantly increasing. It must be clear to every one that soon some new source of power supply must be opened up, or that at least the present methods must be materially improved. A great deal is expected from a more economical utilization of the stored energy of the carbon [illegible] while the attainment of such a result would be hailed as a great achievement, it would not be as much of an advance towards the ultimate and permanent method of obtaining power as some engineers seem to believe.

[illegible] coal mines, and from there transmit the energy to distant points in the form of high-tension alternating currents obtained from stepping transformers, but even in this most favorable case the process would be a barbarous one [illegible] restrict the engineer and mechanic [illegible] by cheap water power, such as some form of oxygen-hydrogen cell.

But we shall not satisfy [illegible] with improving steam and explosive engines [illegible] new batteries; we [illegible] to work for [illegible]. We have to evolve [illegible] for obtaining energy from stores which are forever inexhaustible, [illegible] which do not imply consumption and waste of any material whatever. Upon [illegible] humanity. I have myself [illegible] efforts since a number of years, and a few [illegible] all-dominating problem. I have made progress [illegible] study of known facts, conclusions and calculations [illegible] the realization [illegible] this reason I feel impelled to point out here an [illegible] the medium, I find that even under the theoretically best conditions [illegible] power can [illegible] simplicity and many other features the present method involving a conversion of mechanical energy of running [illegible] electrical energy and the transmission [illegible] of currents of very high tension to great distances. Provided, therefore, that we can avail ourselves of currents of sufficiently high tension, a waterfall affords us the most advantageous means of getting power from the sun sufficient for all our wants [illegible] the water power, not so much because of its commercial value, though it may be very great, but chiefly because [illegible] upon our safety and welfare [illegible] power transmission of electro-motive force much higher than those practicable with ordinary apparatus [illegible] in this field has given me fresh hope that I shall see the fulfillment of one of my fondest dreams; namely, the transmission of power from station to station without the employment of any connecting wire. Still, what [illegible] may appear to many of you [illegible]

unequaled, with commercial facilities and advantages such as few cities in the world possess, and with the enthusiasm and progressive spirit of its citizens, it is sure to [illegible] greatest industrial centers.

[illegible] Editors Enjoy a Trolley Ride.

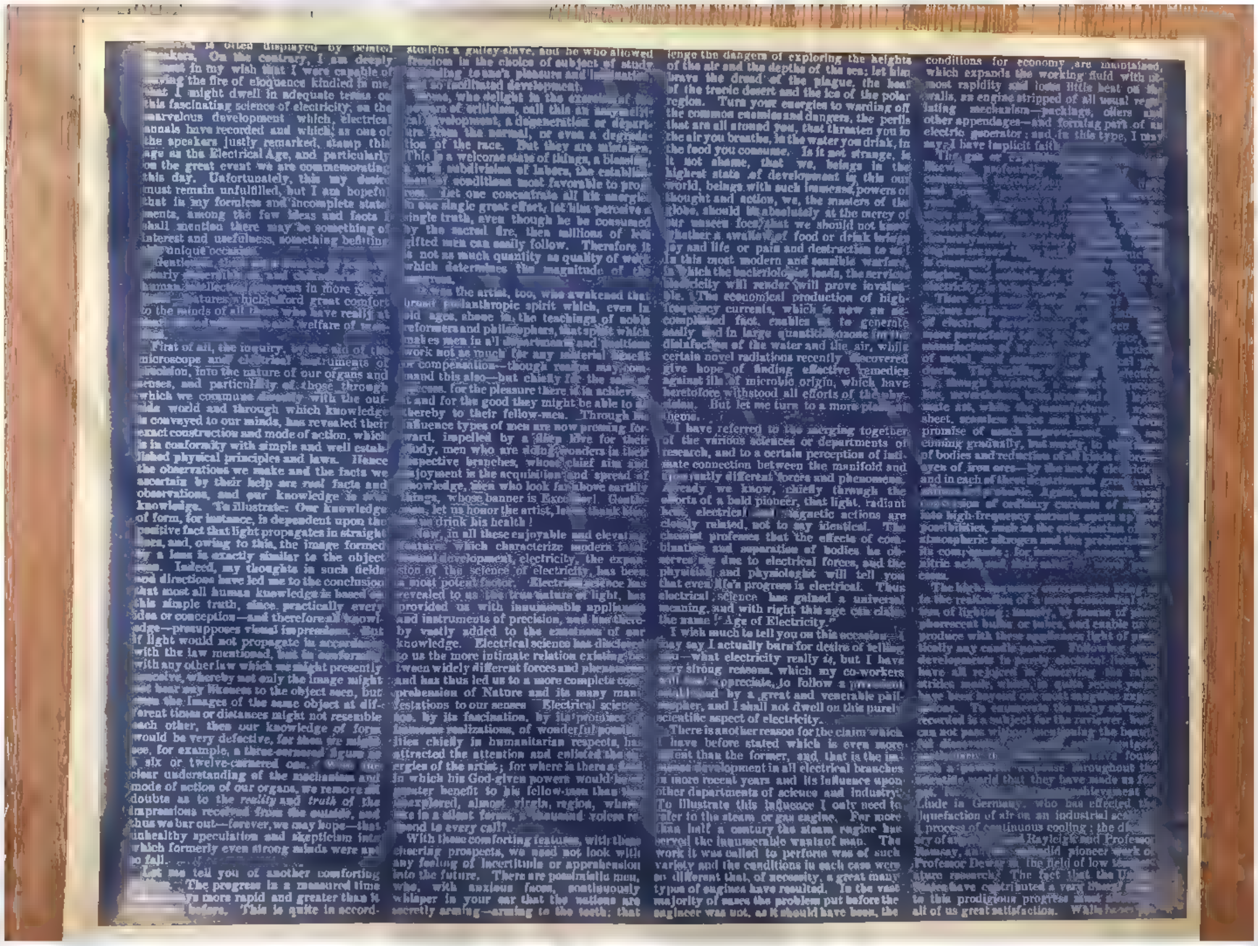
[illegible] Editorial Association [illegible] New York, held [illegible] this city last week. They devoted the afternoon [illegible] trolley ride over Brooklyn in the beautiful parlor [illegible] President Rossiter, [illegible] Railway Company [illegible] the occasion. Lunch was served in the cars and it [illegible] as well as novel [illegible] visiting editors to [illegible] the city of Brooklyn and suburbs while enjoying [illegible]. After the [illegible] Brooklyn Navy [illegible] entertained at a [illegible] Union League Club, Brooklyn, through the courtesy of [illegible] association, Hon. William Berri, proprietor of the [illegible] Union. The after-dinner speeches at the banquet [illegible] interest and were made by the following eminent gentlemen [illegible] Depew, Elihu Root, Paul Dana, W. J. Arkell, [illegible] Joseph Howard, Jr., Henry Watterson and Lieut. R.

Another Reason Why the Cable Should Go.

[illegible] and wave your umbrella at a cable car, and it [illegible] without slowing down [illegible] the gripman until [illegible] in the newspapers [illegible] were injured. It was probably a runaway. The man [illegible] been using [illegible]

[illegible] Belt Manufacturer Assigns.

[illegible] is reported of [illegible] a belt manufacturer [illegible] R. I., who did business [illegible] of A. Bur[illegible]



[illegible] is often displayed by talented speakers. On the contrary, I am deeply [illegible] in my wish that I were capable of [illegible] the fire of eloquence kindled in me, that I might dwell in adequate terms on this fascinating science of electricity, on the marvelous development which electrical annals have recorded and which, as one of the speakers justly remarked, stamp this age as the Electrical Age, and particularly on the great event we are commemorating this day. Unfortunately, this my desire must remain unfulfilled, but I am hopeful that in my formless and incomplete statements, among the few ideas and facts I shall mention there may be something of interest and usefulness, something befitting [illegible] unique occasion.

Gentlemen, [illegible] nearly [illegible] and [illegible] human intellectual progress in more recent [illegible] features which afford great comfort to the minds of all those who have really at [illegible] welfare of man[illegible].

First of all, the inquiry, by the aid of the microscope and electrical instruments of precision, into the nature of our organs and senses, and particularly of those through which we commune directly with the outside world and through which knowledge is conveyed to our minds, has revealed their exact construction and mode of action, which is in conformity with simple and well established physical principles and laws. Hence the observations we make and the facts we ascertain by their help are *real* facts and observations, and our knowledge is *true* knowledge. To illustrate: Our knowledge of form, for instance, is dependent upon the positive fact that light propagates in straight lines, and, owing to this, the image formed by a lens is exactly similar to the object seen. Indeed, my thoughts in such fields and directions have led me to the conclusion that most all human knowledge is based on this simple truth, since practically every idea or conception—and therefore all knowledge—presupposes visual impressions. But if light would not propagate in accordance with the law mentioned, but in conformity with any other law which we might presently conceive, whereby not only the image might not bear any likeness to the object seen, but even the images of the same object at different times or distances might not resemble each other, then our knowledge *of form* would be very defective, for then we might see, for example, a three-cornered figure as a six or twelve-cornered one. [illegible] clear understanding of the mechanism and mode of action of our organs, we remove all doubts as to the *reality* and *truth* of the impressions received from the outside, and thus we bar out—forever, we may hope—that unhealthy speculation and skepticism into which formerly even strong minds were apt to fall.

Let me tell you of another comforting [illegible]. The progress is a measured time [illegible] more rapid and greater than it [illegible] before. This is quite in accord[illegible] student a galley-slave, and he who allowed freedom in the choice of subject of study according to one's pleasure and inclination, and so facilitated development.

[illegible], who delight in the exercise of the powers of criticism, call this an unsymmetrical development, a degeneration or departure from the normal, or even a degradation of the race. But they are mistaken. This is a welcome state of things, a blessing, a wise subdivision of labors, the establishment of conditions most favorable to progress. Let one concentrate all his energies in one single great effort, let him perceive a single truth, even though he be consumed by the sacred fire, then millions of less gifted men can easily follow. Therefore it is not as much quantity as quality of work which determines the magnitude of the [illegible].

It was the artist, too, who awakened that broad philanthropic spirit which, even in old ages, shone in the teachings of noble reformers and philosophers, that spirit which makes men in all departments and positions work not as much for any material benefit or compensation—though reason may command this also—but chiefly for the sake of success, for the pleasure there is in achieving it and for the good they might be able to do thereby to their fellow-men. Through his influence types of men are now pressing forward, impelled by a deep love for their study, men who are doing wonders in their respective branches, whose chief aim and enjoyment is the acquisition and spread of knowledge, men who look far above earthly things, whose banner is Excelsior! Gentlemen, let us honor the artist, let us thank him, let us drink his health!

Now, in all these enjoyable and elevating features which characterize modern intellectual development, electricity, the expansion of the science of electricity, has been a most potent factor. Electrical science has revealed to us the true nature of light, has provided us with innumerable appliances and instruments of precision, and has thereby vastly added to the exactness of our knowledge. Electrical science has disclosed to us the more intimate relation existing between widely different forces and phenomena and has thus led us to a more complete comprehension of Nature and its many manifestations to our senses. Electrical science, too, by its fascination, by its promise of immense realizations, of wonderful possibilities chiefly in humanitarian respects, has attracted the attention and enlisted the energies of the artist; for where is there a field in which his God-given powers would be of greater benefit to his fellow-men than this unexplored, almost virgin, region, where, as in a silent forest, a thousand voices respond to every call?

With these comforting features, with these cheering prospects, we need not look with any feeling of incertitude or apprehension into the future. There are pessimistic men, who, with anxious faces, continuously whisper in your ear that the nations are secretly arming—arming to the teeth; that [illegible] lenge the dangers of exploring the heights of the air and the depths of the sea; let him brave the dread of the plague, the heat of the tropic desert and the ice of the polar region. Turn your energies to warding off the common enemies and dangers, the perils that are all around you, that threaten you in the air you breathe, in the water you drink, in the food you consume. Is it not strange, is it not shame, that we, beings in the highest state of development in this our world, beings with such immense powers of thought and action, we, the masters of the globe, should be absolutely at the mercy of our unseen foes, that we should not know whether a swallow of food or drink brings joy and life or pain and destruction to us? In this most modern and sensible warfare, in which the bacteriologist leads, the services electricity will render will prove invaluable. The economical production of high-frequency currents, which is now an accomplished fact, enables us to generate easily and in large quantities ozone for the disinfection of the water and the air, while certain novel radiations recently discovered give hope of finding effective remedies against ills of microbic origin, which have heretofore withstood all efforts of the physician. But let me turn to a more pleasant theme.

I have referred to the merging together of the various sciences or departments of research, and to a certain perception of intimate connection between the manifold and apparently different forces and phenomena. Already we know, chiefly through the efforts of a bold pioneer, that light, radiant heat, electrical and magnetic actions are closely related, not to say identical. The chemist professes that the effects of combination and separation of bodies he observes are due to electrical forces, and the physician and physiologist will tell you that even life's progress is electrical. Thus electrical science has gained a universal meaning, and with right this age can claim the name "Age of Electricity."

I wish much to tell you on this occasion—I may say I actually burn for desire of telling you—what electricity really *is*, but I have very strong reasons, which my co-workers will well appreciate, to follow a precedent established by a great and venerable philosopher, and I shall not dwell on this purely scientific aspect of electricity.

There is another reason for the claim which I have before stated which is even more potent than the former, and that is the immense development in all electrical branches in more recent years and its influence upon other departments of science and industry. To illustrate this influence I only need to refer to the steam or gas engine. For more than half a century the steam engine has served the innumerable wants of man. The work it was called to perform was of such variety and the conditions in each case were so different that, of necessity, a great many types of engines have resulted. In the vast majority of cases the problem put before the engineer was not, as it should have been, the [illegible] conditions for economy are maintained, which expands the working fluid with utmost rapidity and loses little heat on the walls, an engine stripped of all usual regulating mechanism—packings, oilers and other appendages—and forming part of an electric generator; and in this type, I may say, I have implicit faith. The gas or explosive engine, likewise, [illegible] profoundly [illegible]

[illegible] promise of much improvement [illegible] coming gradually, but surely, to [illegible] of bodies and reduction of all kinds of ores [illegible] of iron ores—by the use of electricity [illegible] and in each of these departments great results [illegible] probable. Again, the economical conversion of ordinary currents of supply into high-frequency currents opens up possibilities, such as the production of [illegible] atmospheric nitrogen and the production of its compounds; for instance, [illegible] nitric acid, and [illegible] cases.

The high-frequency currents are bringing [illegible] the realization of a more economical system of lighting; namely, by means of phosphorescent bulbs or tubes, and enable us to produce with these appliances light of practically any candle-power. Following developments in purely electrical lines, I have all rejoiced in observing the rapid strides made, which in quite recent years have been beyond our most sanguine expectations. To enumerate the many advances recorded is a subject for the reviewer, but I can not pass without mentioning the [illegible] have found [illegible] throughout the scientific world that they have made us feel [illegible] achievement of [illegible] Linde in Germany, who has effected the liquefaction of air on an industrial scale [illegible] process of continuous cooling; the discovery of argon by Lord Rayleigh and Professor Ramsay, and the splendid pioneer work of Professor Dewar in the field of low temperature research. The fact that the United States have contributed a very liberal share to this prodigious progress must afford all of us great satisfaction. While [illegible]

workers in other countries and all those who, by profession or inclination, are devoting themselves to strictly scientific pursuits, we have particular reasons to mention with gratitude the names of those who have so much contributed to this marvelous development of electrical industry in this country. Bell, who, by his admirable invention enabling us to transmit speech to great distances, has profoundly affected our commercial and social relations, and even our very mode of life; Edison, who, had he not done anything else beyond his early work in incandescent lighting, would have proved himself one of the greatest benefactors of the age; Westinghouse, the founder of the commercial alternating system; Brush, the great pioneer of arc lighting; Thomson, who gave us the first practical welding machine, and who, with keen sense, contributed very materially to the development of a number of scientific and industrial branches; Weston, who once led the world in dynamo design, and now leads in the construction of electric instruments; Sprague, who, with rare energy, mastered the problem and insured the success of practical electrical railroading; Acheson, Hall, Willson and others, who are creating new and revolutionizing industries here under our very eyes at Niagara. Nor is the work of those gifted men nearly finished at this hour. Much more is still to come, for, fortunately, most of them are still full of enthusiasm and vigor. All of these men and many more are untiringly at work investigating new regions and opening up unsuspected and promising fields. Weekly, if not daily, we learn through the journals of a new advance into some unexplored region, where at every step success beckons friendly, and leads the toiler to harder and harder tasks.

But among all these many departments of research, these many branches of industry, new and old, which are being rapidly expanded, there is one dominating all others in importance—one which is of the greatest significance for the comfort and welfare, not to say for the existence, of mankind, and that is the electrical transmission of power. And in this most important of all fields, gentlemen, long afterwards, when time will have placed the events in their proper perspective, and assigned men to their deserved places, the great event we are commemorating to-day will stand out as designating a new and glorious epoch in the history of humanity—an epoch grander than that marked by the advent of the steam engine. We have many a monument of past ages; we have the palaces and pyramids, the temples of the Greek and the cathedrals of Christendom. In them is exemplified the power of men, the greatness of nations, the love of art and religious devotion. But that monument at Niagara has something of its own, more in accord with our present thoughts and tendencies. It is a monument worthy of our scientific age, a true monument of enlightenment and of peace. It signifies the subjugation of natural forces to the service of man, the discontinuance of barbarous methods, the relieving of millions from want and suffering. No matter what we attempt to do, no matter to what fields we turn our efforts, we are dependent on power. Our economists may propose more economical systems of administration and utilization of resources, our legislators may make wiser laws and treaties, it matters little; that kind of help can be only temporary. If we want to reduce poverty and misery, if we want to give to every deserving individual what is needed for a safe existence of an intelligent being, we want to provide more machinery, more power. Power is our mainstay, the primary source of our many-sided energies. With sufficient means we are driven to the general adoption of a system of energy supply from central stations, and for such purposes the beauties of the mechanical generation of electricity can not be exaggerated. The advantages of this universally accepted method are certainly so great that the probability of replacing the engine dynamos by batteries is, in my opinion, a remote one, the more so as the high-pressure steam engine and gas engine give promise of a considerably more economical thermodynamic conversion. Even if we had this day such an economical coal battery, its introduction in central stations would by no means be assured, as its use would entail many inconveniences and drawbacks. Very likely the carbon could not be burned in its natural form as in a boiler, but would have to be specially prepared to secure uniformity in the current generation. There would be a great many cells needed to make up the electro-motive force usually required. The process of cleaning and renewal, the handling of nasty fluids and gases and the great space necessary for so many batteries would make it difficult, if not commercially unprofitable, to operate such a plant in a city or densely populated district. Again, if the station be erected in the outskirts, the conversion by rotating transformers or otherwise would be a serious and unavoidable drawback. Furthermore, the regulating appliances and other accessories which would have to be provided would probably make the plant fully as much, if not more, complicated than the present. We might, of course, place the batteries at or near the coal mine, and from there transmit the energy to distant points in the form of high-tension alternating currents obtained from rotating transformers, but even in this most favorable case the process would be a barbarous one, certainly more so than the present, as it would still involve the consumption of material, while at the same time it would restrict the engineer and mechanic in the exercise of their beautiful art. As to the energy supply in small isolated places as dwellings, I have placed my confidence in the development of a light storage battery, involving the use of chemicals manufactured by cheap water power, such as some carbide or oxygen-hydrogen cell.

But we shall not satisfy ourselves simply with improving steam and explosive engines or inventing new batteries; we have something much better to work for, a greater task to fulfill. We have to evolve means for obtaining energy from stores which are forever inexhaustible, to perfect methods which do not imply consumption and waste of any material whatever. Upon this great possibility, which I have long ago recognized, upon this great problem, the practical solution of which means so much for humanity, I have myself concentrated my efforts since a number of years, and a few happy ideas which came to me have inspired me to attempt the most difficult, and given me strength and courage in adversity. Nearly six years ago my confidence had become strong enough to prompt me to an expression of hope in the ultimate solution of this all-dominating problem. I have made progress since, and have passed the stage of mere conviction such as is derived from a diligent study of known facts, conclusions and calculations. I now feel sure that the realization of that idea is not far off. But precisely for this reason I feel impelled to point out here an important fact, which I hope will be remembered. Having examined for a long time the possibilities of the development I refer to, namely, that of the operation of engines on any point of the earth by the energy of the medium, I find that even under the theoretically best conditions such a method of [illegible] would judge them more justly if you would have devoted your life to them, as I have done. With ideas it is like with dizzy heights you climb: At first they cause you discomfort and you are anxious to get down, distrustful of your own powers; but soon the remoteness of the turmoil of life and the inspiring influence of the altitude calm your blood; your step gets firm and sure and you begin to look—for dizzier heights. I have attempted to speak to you on "Electricity," its development and influence, but I fear that I have done it much like a boy who tries to draw a likeness with a few straight lines. But I have endeavored to bring out one feature, to speak to you in one strain which I felt sure would find response in the hearts of all of you, the only one worthy of this occasion—the humanitarian. In the great enterprise at Niagara we see not only a bold engineering and commercial feat, but far more, a giant stride in the right direction as indicated both by exact science and philanthropy. Its success is a signal for the utilization of water powers all over the world, and its influence upon industrial development is incalculable. We must all rejoice in the great achievement and congratulate the intrepid pioneers who have joined their efforts and means to bring it about. It is a pleasure to learn of the friendly attitude of the citizens of Buffalo and of the encouragement given to the enterprise by the Canadian authorities. We shall hope that other cities, like Rochester on this side and Hamilton and Toronto in Canada, will soon follow Buffalo's lead. This fortunate city herself is to be congratulated. With resources now unequaled, with commercial facilities and advantages such as few cities in the world possess, and with the enthusiasm and progressive spirit of its citizens, it is sure to become one of the greatest industrial centers of the globe.

Editors Enjoy a Trolley Ride.

The Republican Editorial Association of the State of New York, held its annual meeting in this city last week. They devoted the afternoon of Thursday to a trolley ride over Brooklyn in the beautiful parlor trolley cars which President Rossiter, of the Brooklyn Street Railway Company, provided for the occasion. Lunch was served in the cars and it was a very enjoyable as well as novel experience for the visiting editors to be whirled through the city of Brooklyn and suburbs while enjoying an excellent repast. After the ride they visited the Brooklyn Navy Yard, and were later entertained at a banquet at the Union League Club, of Brooklyn, through the courtesy of the president of the association, Hon. William Berri, proprietor of the Brooklyn Standard Union. The after-dinner speeches at the banquet were of unusual interest and were made by the following eminent gentlemen: Chauncey M. Depew, Elihu Root, Paul Dana, W. J. Arkell,

THE NEW YORK ACADEMY OF SCIENCE.

AN INTERESTING ELECTRICAL EXHIBITION — ADDRESS BY NIKOLA TESLA, ANNOUNCING RECENT ACHIEVEMENTS.

The New York Academy of Sciences gave its fourth annual reception and exhibit of recent progress in science in the American Museum of Natural History, New York, April 5 and 6.

In the division devoted to chemistry, in charge of Charles A. Doremus, were exhibited a number of electric furnaces, and in the electrical division, in charge of G. F. Sever, were to be seen a number of historical collections of incandescent and arc lamps, instruments of precision, Crookes tubes, induction coils, etc. Mr. W. H. Meadowcroft exhibited a Thomson 14 inch spark inductorium, and tubes and fluoroscopes, and Dr. M. I. Pupin had on view an induction coil and circuit breaker for the generation of Roentgen rays. Dr. Max Osterberg exhibited some specimens of German tubes, and Dr. Doremus showed one of the original Henry induction coils.

Tuesday evening a large audience assembled to listen to an address by Nikola Tesla on "The Streams of Lenard and Roentgen and Novel Apparatus for their Production". The lecturer had on exhibition a number of his perfected electrical oscillators, designed particularly to be used in place of the induction coils of old type. He exhibited numerous diagrams illustrating results obtained by him in his experiments [illegible] ments exhibited, dwelling [illegible] principles underlying them, [illegible] illustrated, in a few striking [illegible] ments, the practical and econ[illegible] features of the machines [illegible] greatest [illegible] evinced by the audience [illegible] he lighted brilliantly a [illegible] tube with one of his [illegible] ing, as he said, 800,000 [illegible] a second. What rendered [illegible] ticularly valuable, he stated, was [illegible] they worked equally well on alter[illegible] ing or direct-current circuits, [illegible] transform these currents with [illegible] economy into high frequency electrical vibrations.

Mr. Tesla announced two important discoveries relating to the Roentgen rays. First, he said he had discovered a new and powerful source of the rays in an electric arc, formed under peculiar conditions. The second discovery was the deflection of the Roentgen rays by means of a magnet. This discovery is particularly important in establishing the identity of the Roentgen rays, and those discovered by Lenard in 1891, and is, therefore, one of the most valuable contributions to our knowledge of these rays.

Tesla dwelt also on some phenomena of rotation of bodies in bulbs, and, among other things, described his method of determining exactly the speed of a dynamo when taking readings.

To a few interested scientific men Mr. Tesla showed a great number of diagrams illustrating experiments he had performed which tended to prove the correctness of the views he holds in regard to the Roentgen phenomena being caused by material particles projected with great velocity.

The ELECTRICAL REVIEW hopes to be able to present in full, in an early issue, Mr. Tesla's lecture.

The Western Telephone Construction Company Again Victorious — Court Decides Roosevelt

[illegible] fected electrical oscillators, designed particularly to be used in place of the induction coils of old type. He exhibited numerous diagrams illustrating results obtained by him in his experiments, to ascertain the nature of the Roentgen rays. There were over 100 different working drawings of bulbs, showing the extent of the ground covered by the lecturer in this field. There were, besides, a number of remarkable photographs exhibited, which were taken by means of one of the small oscillators exhibited. These instruments and photographs were examined with the keenest interest after the lecture by a large number who remained and insisted on a supplementary lecture, which Mr. Tesla kindly consented to give, notwithstanding that, as he playfully remarked, he had not yet had his dinner.

Mr. Tesla introduced the subject of his lecture by stating that at the close of 1894 he investigated the actinic power of phosphorescent bodies, and during these experiments, which were carried on by the assistance of Tonnelé & Company, photographers of this city, working for the *Century Magazine*, a great number of plates showed curious marks and defects, which were noted both by the speaker and the photographers, but not recognized as being due to the Roentgen rays. Just as he was beginning to look into the nature of the phenomena his laboratory was burned, and before his work was thoroughly resumed in his new laboratory Roentgen's discovery was announced.

[illegible]

at Chicago Judge Grosscup, on the 5th instant, handed down a decision in favor of the Western Telephone Construction Company in the suit brought by the Western Electric Company in October, 1895, alleging infringement of the famous Roosevelt switch, patent No. 215,837, May 27, 1879, under which the Bell company is said to have paid during the life of the patent some $35,000 in royalties to the Roosevelt heirs. The court's decision was subsequently withdrawn for the purpose of revision as to its phraseology. The court held, in effect, that the Roosevelt device was a purely automatic switch; that is, a switch which would operate, without any intent of the operator, to make a change in the circuits, while the defendants' switch, which is identical with the Watson device (the patent on which was declared invalid on February 10 last), was not entirely automatic. In fact, it could not be called automatic in any sense, since the telephone had to be placed on the hook, and if not so placed, the circuit would not be changed, as in the Roosevelt device, where the hand 'phone was suspended by a cord, and the weight of the telephone was the real cause of changing the switch.

The suit has been in the courts for some time, and was earnestly contested on each side, its final outcome reflecting much credit on the argument of defendants' solicitor, Col. S. S. Stout.

[illegible] object, and particularly on [illegible] importance which I have [illegible] some time ago by the aid of [illegible] Lenard tube, and which, if I am [illegible] informed, I can only in part [illegible] as my own, since it seems that practically it has been expressed in other words by Professor Roentgen in his recent communication to the Academy of Sciences of [illegible]. The result alluded to has reference [illegible] much disputed question of the source of the Roentgen [illegible]. It will be [illegible] [illegible] of his discovery, Roentgen was of the opinion that the rays which affected the sensitive layer emanated from the fluorescent spot on the glass wall of the bulb; other scientific men [illegible] made the cathode responsible; still others the anode, while some thought that the rays were emitted solely from fluorescent powders or surfaces, and speculations, mostly unfounded, increased to such an extent that, despairing [illegible] the poet:

"O glücklich wer noch hoffen kann,
Aus diesem Meer des Irrtums aufzutauchen."

My own experiments led me to recognize that, regardless of the location, the chief source of these rays was the place of the *first* impact of the projected stream of particles within the bulb. This was merely a broad statement, of which that of Professor Roentgen was a special case, as in his first experiments the fluorescent spot on the glass wall was, incidentally, the place of the first impact of the cathodic stream. [illegible] investigations carried on up to the present day have only confirmed the correctness of the above opinion, and the place of the first collision of the stream of particles—be it an anode or independent impact body, the glass wall or an aluminum window—is still found to be the principal source of the rays. But, as [illegible] necessary to first show that there is an actual penetration of the particles through the wall, or otherwise that the actions of the supposed streams, of whatever nature they might be, were sufficiently pronounced in the outer region close to the wall of the bulb as to produce some of the effects which are peculiar to a cathodic stream. It was not difficult to obtain with a properly prepared Lenard tube, having an [illegible] thin window, many and at [illegible] surprising evidences of this character. Some of these have already been pointed out, and it is thought sufficient to cite here one more which I have since observed. In the hollow aluminum cap A of a tube as shown in diagram Fig. [illegible] which will be described in detail, I placed a half-dollar silver piece, supporting it at a small distance from and parallel to the window or bottom of the cap by strips of mica in such a manner that it was not

Fig. 2.—Improved Lenard Tube.

touching the metal of the tube, an air space being left all around it. Upon exciting the bulb for about 30 to 45 seconds by the secondary discharge of a powerful coil of a novel type now well known, it was found that the silver piece was rendered so hot as to actually scorch the hand; [illegible] the aluminum window, which offered a very insignificant obstacle to the cathodic stream, was only moderately warmed. Thus it was shown that the silver alloy, owing to its density and thickness, took up most of the energy of the impact, being acted upon by the particles almost identically as if it had been

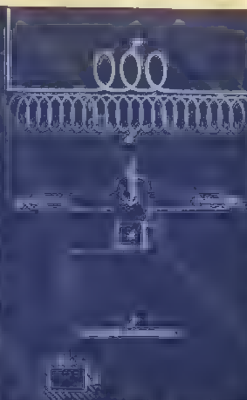


Fig. 3.—Illustrating Arrangement with Improved Double-Focus Tube for Reducing the Injurious Action.

improved design, consisting of a tube T of thick glass tapering towards the open end, or neck n, into which is fitted an aluminum cap A, and a spherical cathode s, supported on a glass stem s, and platinum wire w sealed in the opposite end of the tube as usual. The aluminum cap A, as will be observed, is not in actual contact with the ground-glass wall, being held at a small distance from the latter by a narrow and continuous ring of tinfoil r. The outer space between the glass and the cap A is filled with cement c, in a manner which I shall later describe. F is a Roentgen screen such as is ordinarily used in making the observations.

Now, in looking upon the screen in the direction from F to T, the dark lines indicated on the lower part of the diagram were seen on the illuminated background. The curved lines [illegible] space outside of the bulb towards the aluminum cap, and chiefly from the region through which the primary disturbances or streams emitted from the tube through the window were passing, which observation could not be explained in a more plausible manner than by assuming that the air and dust particles outside, in the path of the projected streams, afforded an obstacle to their passage and gave rise to impacts and collisions, spreading through the air in all directions, thus producing continuously new sources of the rays. It is this fact which, in his recent communication before mentioned, Roentgen has brought out. So, at least, I have interpreted his reported statement that the rays emanate from the irradiated air. It now remains to be shown whether the air, from which carefully all foreign particles are removed, is capable of behaving as an impact body and source of the rays, in order to decide whether the generation of the latter is dependent on the presence in

Fig. [illegible].—Illustrating Arrangement with a Lenard Tube for [illegible] Working at Close Range.

the air of impact particles of measurable dimensions. I have reasons to think so.

With the knowledge of this fact we are now able to form a more general [illegible]

(Concluded on page 71.)

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FIG. 2.—IMPROVED LENARD TUBE.

touching the metal of the tube, an air space being left all around it. Upon exciting the bulb for about 30 to 45 seconds by the secondary discharge of a powerful coil of a novel type now well known, it was found that the silver piece was rendered so hot as to actually scorch the hand; yet the aluminum window, which

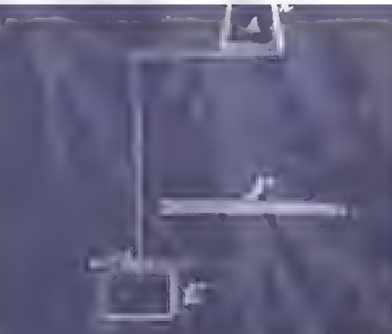

FIG. 3.—ILLUSTRATING ARRANGE
WITH IMPROVED DOUBLE-FOCUS
FOR REDUCING THE INJURIOUS AC

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open end, or neck *n*, into wh
fitted an aluminum cap A,
spherical cathode *c*, supported
glass stem *s*, and platinum w
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...n, consisting of a tube ...s tapering towards the neck n, into which is ...minum cap A, and a ...ode e, supported on a and platinum wire w ...pposite end of the tube aluminium cap A, as will not in actual contact ...und glass wall, being ...all distance from the ...arrow and continuous ...il r. The outer space glass and the cap A cement c, in a manner later describe. F is a ...en such as is ordinarily ...g the observations.

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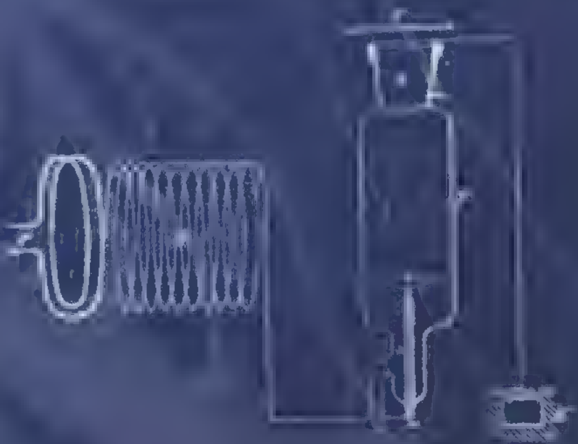

FIG. 4.—ILLUSTRATING ARRANGEMENT WITH A LENARD TUBE FOR SAFE WORKING AT CLOSE RANGE.

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With the knowledge of this fact we

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...ual penetration of the particles
...gh the wall, or otherwise that
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... properly prepared Lenard tube,
... an exceedingly thin window,
... and at first surprising evidences
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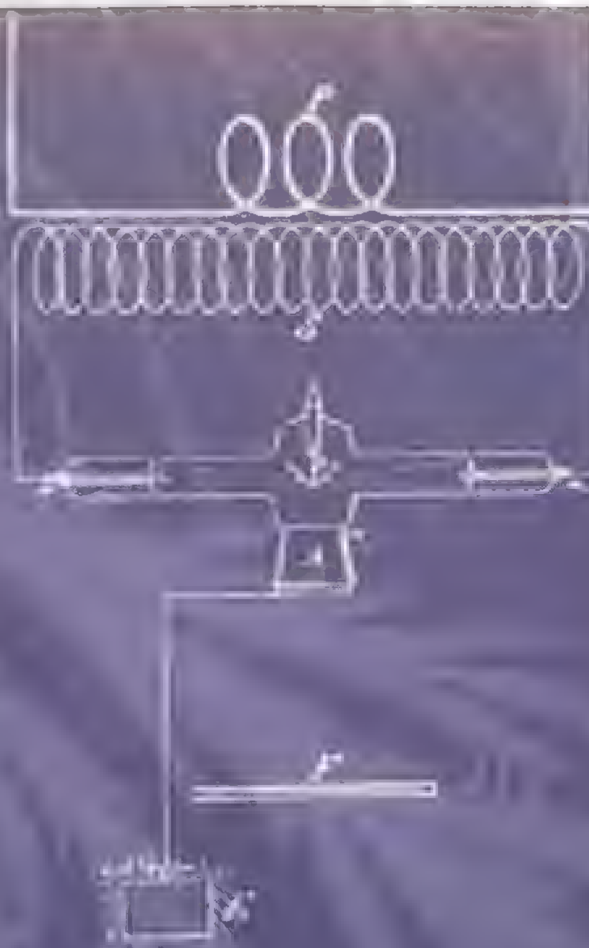

FIG. 3.—ILLUSTRATING ARRANGEMENT WITH IMPROVED DOUBLE-FOCUS TUBE FOR REDUCING THE INJURIOUS ACTIONS.

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[illegible]LA ON ROENTGEN RAYS.

(Concluded from page 67.)

[illegible] of the process of generation of the radiations which have been discovered by Lenard and Roentgen. It may be comprised in the statement that the streams of minute material particles projected [illegible] with great [illegible] obstacle[illegible] in the [illegible] medium [illegible] themsel[illegible] [illegible] ties of those [illegible] physical pro[illegible] these rays [illegible] portant con[illegible] physicists to again [illegible] many phenomena [illegible] attributed to transverse [illegible] waves, which may lead to a radical modification of existing views and theories in regard to these phenomena, if not [illegible] to the[illegible] mode of [illegible]

My effort [illegible] third of [illegible] to the establishment [illegible] of the close relationship which exists between the Lenard and Roentgen rays. The photographs bearing on this point were exhibited at a meeting of the New York Academy of [illegible] before referred to, April [illegible], but, unfortunately, owing [illegible] of my [illegible] and [illegible] of thought [illegible] other matters [illegible] what was most important, namely, to describe the manner in which these photographs were obtained, an oversight which I was able to only partially repair the day following. I did, however, on that occasion illustrate and describe experiments, in which was shown the deflectibility of the Roentgen rays by a magnet, which establishes a still closer relationship, if not identity, of the rays named

[illegible]scribed, in which the primary is operated by the discharges of a condenser. With such an instrument any desired suddenness of the impulses may be secured, there being practically no limit in this respect, as the energy accumulated in the condenser is the most violently explosive [illegible] know, and any potential [illegible] [illegible] the same tube [illegible] with the ordinary coil [illegible] low [illegible] of change [illegible] current [illegible] practically [illegible] even when, as before [illegible] more energy, as judged [illegible] the heating, was passed through [illegible] This [illegible]rience, together with [illegible] I have succeeded in [illegible] by the use of immense electrical pr[illegible] obtainable with certain apparatus [illegible] for this [illegible] some impressions [illegible] free a[illegible] conclusion [illegible] discharges [illegible] must [illegible] pressure.

At this [illegible] of the preceding lines, that my scientific interest has dominated the practical, and that the following remarks must be devoted to the primary [illegible] this communication—that is [illegible] some data for the construct[illegible] those engaged in the manufacture of the tubes and, perhaps, a few useful hints to practicing physicians who are dependent on such information. The foregoing was, nevertheless, not lost for this object, inasmuch as it has shown how much the result obtained depends on the proper construction of the instruments, for, with ordinary implements, most of the above observations could

outside, as is frequently done. Long experience has demonstrated that it is practically impossible to maintain a high vacuum in a tube with an outside cap. The only way I have been able to do this in a fair measure [illegible] by cooling the cap by a jet of [illegible] for instance, and observing the following precautions: [illegible] first turned [illegible] slight[illegible] [illegible] the latter, and also [illegible] [illegible] completing the [illegible] pressure and current through the tube are both gradually reduced and both so manipulated that no great differences in temperature result between the glass and aluminum cap. If these precautions are not observed the vacuum will be immediately impaired in consequence of the uneven expansion of the [illegible] metal.

With tubes [illegible] it is quite unnecessary to observe this precaution if proper [illegible] taken in their preparation [illegible] inserting the cap the latter is cooled down as low as it is deemed advisable without endangering the glass, and it is then gently pushed in the end of the tube, taking care that [illegible] straight.

The two most important [illegible] in the manufacture of such a tube are, however, the thinning down of the aluminum window and the sealing in of the cap. The metal of the latter may be one thirty-second or even one-sixteenth of an inch thick, and in such case the central portion may be thinned down by a countersink tool about one-fourth of an inch [illegible] diameter as far as it [illegible] without tearing [illegible] thinning down may [illegible] done by hand with a scraping tool and, finally, the metal should [illegible] gently beaten down so as to [illegible] close the pores which might permit a slow leak. Instead of proceeding in this way I have employed a cap with a hole in the center, which I have closed with a sheet of pure aluminum a few thousandths of an inch thick, [illegible]

may be done first with acid, then with highly diluted alkali, next with distilled water, and finally with pure rectified alcohol.

These tubes, when properly prepared, give impressions much sharper and reveal much more detail than those of ordinary make. It is important for the clearness of the impressions that the electrode should [illegible] and that the [illegible] exactly in the center [illegible] of the [illegible] Fig. [illegible] which [illegible] It will be seen that in each of the [illegible] [illegible] of a few seconds only at close range, inasmuch as, during the operation of the bulb, one can easily [illegible] the arrangement shown in Fig. [illegible] particularly advantageous with [illegible] of single terminal, which [illegible] I have described on other occasions and which is diagrammatically illustrated, P being the primary and S the secondary. In this instance the high-potential terminal is connected [illegible] the electrode, while the cap is [illegible] may be placed [illegible] the patient [illegible] in the drawing, under the operating table and [illegible] contact with [illegible] body of the patient, if the impression requires only a few seconds as, for instance, in examining parts of the members. I have taken many impressions with such tubes and have observed no injurious action,

[illegible] ON THE SOURCE OF ROENTGEN RAYS AND THE PRACTICAL CONSTRUCTION AND SAFE OPERATION OF LENARD TUBES.

To the Editor of Electrical Review :

I have for some time felt that a few indications in regard to the practical construction of Lenard tubes of improved designs, a great number of which I have recently exhibited before the New York Academy of Sciences (April 6, 1897), would be useful and timely, particularly as by their proper construction and use much of the danger attending the experimentation with the rays may be avoided. The simple precautions which I have suggested in my previous communications to your esteemed journal are seemingly disregarded, and cases of injury to patients are being almost daily reported, and in view of this only, were it for no other reason, the following lines, referring to this subject, would have been written before had not again pressing and unavoidable duties prevented me from doing so. A short and, I may say, most unwelcome interruption of the work which has been claiming my attention makes this now possible. However, as these opportunities are scarce, I will utilize the present to dwell in a few words on some other matters in connection with this subject, and particularly on a result of importance which I have reached some time ago by the aid of such a Lenard tube, and which, if [illegible] I can only in part [illegible], since it seems that practically it has been expressed in other words by Professor Roentgen in a recent communication to the Academy of Sciences of Berlin. The result alluded to has reference to the much disputed question of the source of the Roentgen rays. As will be remembered, in the first announcement [illegible] will be seen presently, it is not the only source.

Since recording the above fact my efforts were directed to finding answers to the following questions: First, is it necessary that the impact body should be within the tube? Second, is it required that the obstacle in the path of the cathodic stream should be a solid or liquid? And, third, to what extent is the velocity of the stream necessary for the generation of and influence upon the character of the rays emitted?

In order to ascertain whether a body located outside of the tube and in the

FIG. 1.—[illegible] EXPERIMENT [illegible] ROENTGEN RAYS.

path or in the direction of the stream of particles was capable of producing the same peculiar phenomena as an object located inside, it appeared necessary to first show that there is an actual penetration of the particles through the wall, or otherwise that the actions of the supposed streams, of whatever nature they might be, were sufficiently pronounced in the outer region close to the wall of the bulb as to produce some of the effects which are peculiar to a cathodic stream. It was not difficult to obtain with a properly prepared Lenard tube, having an exceedingly thin window, many and at first surprising evidences [illegible] inside of the bulb, and, what is more, indications were obtained, by observing the shadows, that it behaved like a second source of the rays, inasmuch as the outlines of the shadows, instead of being sharp and clear as when the half-dollar piece was removed, were dimmed. It was immaterial for the chief object of the inquiry to decide by more exact methods whether the cathodic particles actually penetrated the window, or whether a new and separate stream was projected from the outer side of the window. In my mind there exists not the least doubt that the former was the case, as in this respect I have been able to obtain numerous additional proofs, upon which I may dwell in the near future.

I next endeavored to ascertain whether it was necessary that the obstacle outside was, as in this case, a solid body, or a liquid, or broadly, a body of measurable dimensions, and it was in investigating in this direction that I came upon the important result to which I referred in the introductory statements of this communication. I namely observed rather accidentally, although I was following up a systematic inquiry, what is illustrated in diagram Fig. 1. The diagram shows a Lenard tube of [illegible]

[illegible] course, at once recognized as the outlines of the cathode c and the bottom of the cap A respectively, although, in consequence of a confusing optical illusion, they appeared [illegible] together than they actually [illegible]. For instance, if the distance [illegible] c and c was [illegible] inches, these lines would appear on the screen [illegible] two inches apart, as [illegible] judge by the eye. This illusion may be easily explained and [illegible] unimportant, except that [illegible] be of some moment to physicians to keep this fact in mind when making examinations with the screen, as, owing to the above [illegible] sometimes exaggerated to a degree hard to believe, a completely erroneous idea of the distance of the various parts of the object under examination might be gained, to the detriment of the surgical operation. But while the lines c and b were easily accounted for, the curved lines f, g, e were at first puzzling. Soon, however, it was ascertained that the faint line e was the shadow of the edge of the [illegible] darker line g [illegible] of the glass tube T, and f the shadow of the tinfoil ring r. These [illegible] screen F clearly showed that [illegible] agency which affected the [illegible] material was proceeding from the space outside of the bulb towards the aluminum cap, and chiefly from the region through which the primary [illegible] were [illegible] through the window [illegible] passing, which observation could not be explained [illegible] manner than by assuming [illegible] air and dust particles outside [illegible] path of the projected streams, afforded an obstacle to their passage and gave rise to impacts and collisions [illegible]

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work which has been
attention makes this
However, as these op-
re scarce, I will utilize
to dwell in a few words
r matters in connection

in the path of the cathodic stream should be a solid or liquid? And, third, to what extent is the velocity of the stream necessary for the generation of and influence upon the character of the rays emitted?

In order to ascertain whether a body located outside of the tube and in the

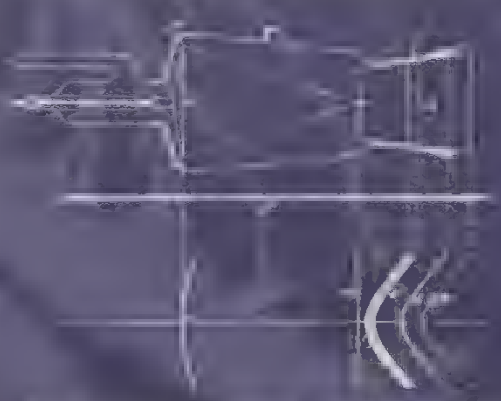


FIG. 1.—ILLUSTRATING AN EXPERIMENT REVEALING THE REAL SOURCE OF THE ROENTGEN RAYS.

path or in the direction of the stream of particles was capable of producing the same peculiar phenomena as an object located inside, it appeared

material for the chief object of
inquiry to decide by more
methods whether the cathodic
ticles actually penetrated the win
or whether a new and separate st
was projected from the outer sid
the window. In my mind t
exists not the least doubt that
former was the case, as in this res
I have been able to obtain nume
additional proofs, upon which I
dwell in the near future.

I next endeavored to asce
whether it was necessary that
obstacle outside was, as in this
a solid body, or a liquid, or bro
a body of measurable dimensi
and it was in investigating in
direction that I came upon
important result to which I ref
in the introductory statements
this communication. I namely
served rather accidentally, althou
was following up a systematic inqu
what is illustrated in diagram Fi
The diagram shows a Lenard tu

...LUSTRATING AN EXPERIMENT ...ING THE REAL SOURCE OF THE ...EN RAYS.

the direction of the stream s was capable of producing peculiar phenomena as an ated inside, it appeared to first show that there is penetration of the particles be wall, or otherwise that of the supposed streams, er nature they might be, ciently pronounced in the on close to the wall of the produce some of the effects e peculiar to a cathodic It was not difficult to obtain perly prepared Lenard tube, n exceedingly thin window, l at first surprising evidences

direction that I came upon the important result to which I referred in the introductory statements of this communication. I namely observed rather accidentally, although I was following up a systematic inquiry, what is illustrated in diagram Fig. 1. The diagram shows a Lenard tube of

t, g, a were at first
however, it was asce
faint line a was th
edge of the aluminu
darker line g that o
glass tube T, and t t
tinfoil ring r. The
screen F clearly s
agency which affect
material was proce
space outside of the
aluminum cap, and
region through wh
disturbances or strea
the tube through t
passing, which clear
be explained in a
manner than by ass
air and dust particle
path of the projected
an obstacle to their
rise to impacts and

To bring out clearly the significance
of the photographs in question,
With this object in view, I showed that phosphorescence and most of the phenom
Electric Light Plant Wanted
Mr. T. J. Lillard, treasurer of
Elkin Manufacturing Company,
dences with eight lights each.

[illegible]

... end of the century ... with scientific ... [illegible] and otherwise, that ... [illegible], become ... ded, and truly we wonder at nothing.

When one reads the account of Mr. Tesla's latest work in electric power ... mission the mental question ... and why not?" Once he had ... [illegible] ... activity it was but a ... transmission, ... means for trans... [illegible]

... [illegible] ... awe-inspir... the light... [illegible] ... ndous bolt dart from ... ing cloud to earth and ... [illegible] ... return stroke?" And ... the cloud, though ... length, has not constituted an ... circuit in such case?

It is my belief that the upper stra... are constantly carrying electrical cur... rents of high potential.

An old-fashioned apparatus for the ... dy of electrical phenomena was a globe of sulphur or glass, which, when rotated under slight friction of the ... hands, produced the desired effect in the shape of a snappy spark. Such a globe was about one foot diameter. What, then, should be the effect of the earth rotating at its enor... speed under the friction of the atmo... phere—a globe billions of times the ... surface of the archaic electric ma... chine?

It is no wonder that our most ad... vanced meteorologists go ... in their forecasts, when they have ... means of learning what is going on ... upper strata.

Tesla's balloon termi... ... to meteorology ... ... own purpose al... for the ... as a source of information o... ... ious phenome... ... here ... And, as the ... ICAL REVIEW has often point...

John ... [illegible]

... [illegible] ... industry ... world ... last week of the ... Company, ma... cars in New ... company is the old... business, and built ... ever used. On the ... dent, Davis and Secre... to the effect that the ... temporarily embarr... Cohen appointed Alb... of Paterson, N. J., an... ... York, received ... hands of ... are plac... ... and the liabiliti... The reason for the ... time is said ... working capi... plant now unde... ... Paterson ... that the ... [illegible] ... was founded by ... who ...

... Duty on ... Lamps

The Board of ... United States ... week announ... the tariff on incan... lamps. The collec... New York assessed ... cent ad valorem, un... 100, act of 1897, which ... articles of glass, or of ... material of chief v... ... protest ... Knauth, Na... holds tha... [illegible] ... further that the ... paragraph ... facture ... ponent m... ... [illegible]

[illegible]

... wonder that our ... meteorologis... [illegible]

... the effect ... temporarily embar... appointed ... [illegible] ... working capital is ... [illegible] ... be reorga... [illegible]

its ulti-

ch as to

r Boise, place it among

al and Tesla first

become

exchange

to the

advantag

name

recent

al distribu-

red by his

will be pos-

that fact

by a line

world

ded advant

Tesla

be pos- mate develo

Boise.

[illegible] EARTH AND ITS ATMOSPHERE.

A CRITICISM AND [illegible]

[illegible] INQUIRY.

To the Editor of Electrical [illegible]:

In your issue of November [illegible] article dated New [illegible] and entitled "Tesla's [illegible] [illegible] Transmission," [illegible] J. M. says: "What [illegible] then, should [illegible] of the earth [illegible] enormous speed [illegible] [illegible] be [illegible] enormous [illegible] [illegible] phenomena of the atmosphere.

[illegible] capable of giving astonishing electrical manifestations, and in the upper strata electrical excitement of a most [illegible] character would not, if manifested, cause any surprise to the modern thinker. What is a storm, if it be not a condition attended by the friction of the lower strata upon the [illegible] and probably of the [illegible] against the higher strata [illegible] the storm may be, and [illegible] simultaneously over an area [illegible] of more.

In the absence of the right sort of facts, namely, observations and [illegible] going on away up in our atmosphere, no one can say what is [illegible] of these great areas [illegible] high and low pressure.

[illegible] one can look up and [illegible] several strata of clouds, each [illegible] moving in an independent direction, proving the existence of stratum [illegible] clouds being merely the [illegible] and having [illegible] relation [illegible] bearing upon the [illegible] of independently moving layers of air and the friction necessarily could generate stupendous amounts of electricity. And it is quite as easy to believe—indeed, it would [illegible] necessary to believe—that there [illegible] in the atmosphere movements just [illegible] [illegible] [illegible] [illegible] [illegible] tion.

New York, November [illegible]

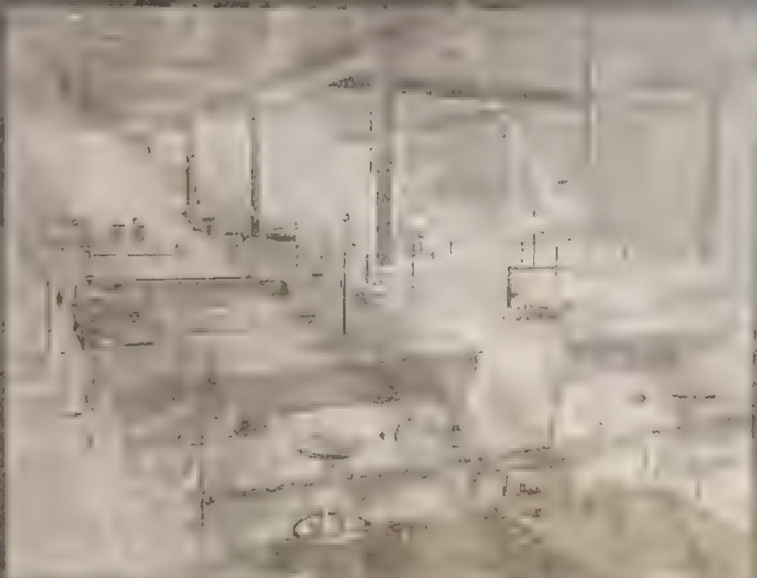


FIG. [illegible]

An Extensive Interior Telephone [illegible]

[illegible] system has recently [illegible] by the Strom[illegible] [illegible] Company [illegible] offi[illegible] [illegible] Com[illegible] nue [illegible] Ohi[illegible] plant affords a good example of the [illegible] of the use and convenience of private [illegible] systems. In Fig. [illegible] is shown an interior view of one of

[illegible] a system [illegible] where inde[illegible] exchanges h[illegible] private sys[illegible] with the [illegible] separate tel[illegible] The system [illegible] generator [illegible]

THE EARTH AND ITS ATMOSPHERE.

A CRITICISM AND ITS ANSWER.

AN INQUIRY.

To the Editor of Electrical Review:

In your issue of November 2, in an article dated New York, October 29, [illegible]

capable of giving astonishing electrical manifestations, and in the upper strata electrical excitement of a most intense character would not, if manifested, cause any surprise to the modern thinker. What is a storm, if it be not a condition attended by the [illegible]

could generat[illegible] of electrici[illegible] believe[illegible] in the at[illegible] like the [illegible] subject as [illegible] tation [illegible]

FIG. 6.—BOOKKEEPING DEPARTMENT EQUIPPED WITH STROMBERG [illegible]

transmission," T. J. M. says: "What, then, should be the effect of the earth rotating at its enormous speed under [illegible] billions of times the surface of the [illegible]

If I [illegible] "frict[illegible] [illegible] with the earth. Did it not, we should be swept from its surface by the enormous velocity of our motion through the atmosphere.

[illegible] the atmosphere [illegible]

earth's surface, and probabl[illegible] lower strata against the higher strata of air? Yet the storm may be, and [illegible] of a million square miles or more. [illegible] the primary cause of these great areas of high and low pressure.

Many days one can look up and observe several strata of clouds, each [illegible] independent direc[illegible] [illegible]istence of stratum[illegible] being merely the [illegible]nters, and having [illegible]earing upon the [illegible]dly moving layers [illegible] the friction necessarily

[illegible] Sy[illegible]

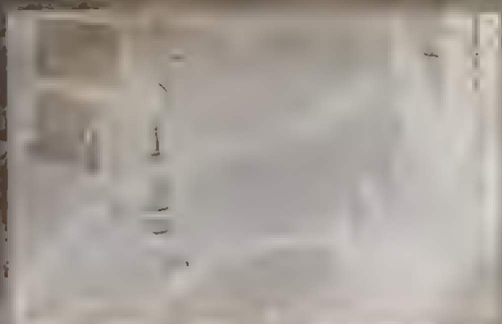
An unusually large and conven[illegible] telephone system has recently been [illegible] Ch[illegible] nue and [illegible] Chicago. The [illegible] plant aff[illegible] ample of [illegible] the use and con[illegible] of private telephone systems. In Fig. 2 is shown an interior view of one of

telephones [illegible] generator [illegible]

ELECTRICAL REVIEW

…onon is carefully …

entire apparatus lifted three feet …



… Telephone Pipe Box

[illegible]ansmission," T. J. M. says: "What [illegible]n, should be the effect of the earth [illegible]g at its enormous speed *under the friction of the atmosphere*—a globe [illegible] times the [illegible]rface of the [illegible] machine[illegible]

[illegible]t mistaken, there is no "friction of the atmosphere" *with* [illegible] atmosphere [illegible] with the earth [illegible] it not, we sh[illegible] be swept from [illegible] surface by the en[illegible] elocity of our motion through the atmospher[illegible]

There is no fr[illegible] upper surface of the atmosphere, for there is absolutely nothing to c[illegible] friction.

It seems to me that T. J. M. must seek another explanation of the source of electricity that causes [illegible] electrical phenomena of the atmosphere.

S. R. M.

Ithaca, N. Y., November 4.

THE ANSWER.

To the Editor of Electrical Review:

If "S. R. M." had [illegible] discriminat[illegible]ingly he would have u[illegible]tood differ[illegible]ently. As a whole, the earth and [illegible] atmosphere move [illegible] at least [illegible] text-boo[illegible] consider the [illegible] great dis[illegible]

[illegible] the storm [illegible] often is, raging furiously over [illegible] of a million square miles or [illegible]

In the absence of the [illegible]ort[illegible] data, namely, observations and [illegible] of what is going on away up in [illegible] atmosphere, no one can say what is the primary cause of these great areas [illegible] high and low pressu[illegible]

Many days one can look up and [illegible] strata of clouds, each layer moving in an independent [illegible] friction, the clouds being merely the finger-bo[illegible]rs, and having no relation [illegible] upon the fact of independently m[illegible]ing layers of air and the [illegible]ecessarily [illegible]ering.

And what is the cause of the steadily [illegible] trade-winds in differ[illegible] parts of the world? Why is it th[illegible] in a given locality the most [illegible]tive wind-storm[illegible] always blow in the same direction? Text[illegible] to the con[illegible]trary, [illegible]ted that there is no friction between the earth and its [illegible] idea of some fric[illegible] and how the [illegible] caused can[illegible] And a [illegible] disturbance [illegible]

[illegible] Company, Michiga[illegible] nue and Adams [illegible] Chicago [illegible] affords a go[illegible] ample of the [illegible] the use and conver[illegible] of private telephon[illegible] ems. In Fig. 2 is [illegible] an interior vi[illegible] the gas comp[illegible] [illegible] offices on th[illegible] [illegible]or, showing six [illegible] [illegible]phone [illegible] [illegible] each windo[illegible] [illegible] three telephon[illegible] [illegible] with the [illegible] [illegible]ed with [illegible] [illegible] illustr[illegible] [illegible] instru[illegible] [illegible] with [illegible]

Under enclose[illegible] a letter which is [illegible] you consider [illegible] insert it in your next issue kindly [illegible]

Yours very truly,

[illegible]

ELECTRICAL ENGINEER ASKED TO EXPLAIN

New York, Nov. 1[illegible], 1[illegible]
[illegible] and 4[illegible] East Houston St.

[illegible] your columns [illegible] recent con[illegible] the Electro-Therapeutic [illegible] you have [illegible]lly succeeded [illegible] many [illegible] made dur[illegible] a number [illegible] causing [illegible] cost me [illegible] pains to write [illegible] papers and [illegible] expected to see it appear among [illegible] dignified contribution[illegible] the wound [illegible] will have no oppo[illegible] similar one [illegible] you have secured [illegible] periodical [illegible] occasion you have offended [illegible]

PERSONAL

Mr. R. J. R[illegible]dolph, manager of the Sterli[illegible] Company, New York [illegible] York for a flying trip [illegible]

Capt. T. H. Brad[illegible] well known in [illegible] and one of the [illegible] electrical good[illegible] member of the Hou[illegible] tives of his state [illegible] many friends will co[illegible] and the state of Conne[illegible] of a capable and cons[illegible]

It was announced [illegible] president Timothy D[illegible] [illegible]ed his position [illegible] Yale University, and [illegible] L. Brush had resigned [illegible] director of the Shef[illegible] School of Yale Uni[illegible] Russell H. Chittenden [illegible] succeed Director Br[illegible] Brush has been made [illegible] in the Sheffield S[illegible]

Mr. R. Edwin[illegible] [illegible] actively taking up hi[illegible]

[illegible]ed, but in my qualities both as Christian and philosopher, I have [illegible] forgiven you and have only [illegible] you for your errors. This time, [illegible] your offense is graver than [illegible]

[illegible] a shadow on my honor.

[illegible] doubt you must have in your [illegible] tangible proofs [illegible] of your statements reflecting [illegible] honesty. Being a board [illegible] from [illegible] universities, it is my duty, [illegible] view of the slur thus cast upon them, [illegible] your [illegible]

[illegible] other [illegible]

[illegible]pany. He returned [illegible] States Commission [illegible] position and is now [illegible] Astoria [illegible] Dra[illegible] the position as chief [illegible] cal and electrical de[illegible] United States sectio[illegible] of the committee [illegible] office will be in Chic[illegible]

[illegible] N [illegible]

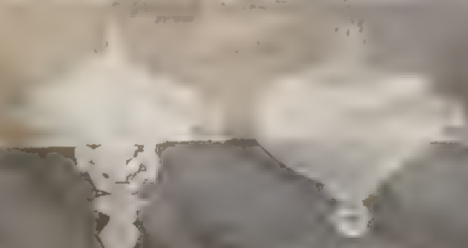
[illegible] phone and [illegible] after [illegible] [illegible]opolis of nearly fo[illegible] the telephone and [illegible] and has developed h[illegible] it is one of the soli[illegible] the country. The [illegible] sponsibilities of his [illegible] tion have [illegible] temperament [illegible] his friends in New Y[illegible]

currents produced by ... ratus, was easily traver... rents furnished by my impr... chine, giving a tension of ... 2,500,000 volts ... vestigation in this direc... another valuable fact; nam... conductivity of the ...

its degree of rarefaction, and at ... the transmission of energy through the upper strata of the air, which, without such results as I have ob-...

This appears all the more certain, as I found it quite practicable to transmit, under conditions such as exist in heights well explored, electrical energy in large amounts. I have thus ... originally stood in the way, and the success of my system now rests merely on engineering skill.

... my latest invention, ... out a point which has ... looked. I arrived, as has ... the idea through ... speculations on the ... which ... machine, the ... pressi...



...osed Arc Lamp

... how, with such a principle brought to great perfection, as it undoubtedly will be in the course of time, guns can maintain themselves as weapons. We shall be able, by ... tance, it will not be limited in any way by weight or amount of explosive charge, we shall be able to submerge it at command, to arrest it in its flight, and call it back, and to send it out again and explode it ... more than this, it will ... miss, since all chance in ... hitting the object of at... required, is eliminated. But ... chief feature of such a weapon ... respond only to a certain note or tune ... it may be endowed with selective power. Directly such an arm is pro...

... distance, to ... much greater dis-...

amperes, and, with one trimming, has a life of from 130 to 150 hours, requiring no attention during that time. These carbons are ... proportioned that ... lower carbon-holder for the next run ... light is of less volume and more violet in color than standard ... lamps, but the ad...

upper carbon at the end of any ... 130 or 150 hours may be placed in the lower carbon-holder for ...

currents produced [illegible] ... as easily t[illegible] ... [illegible]shed by [illegible] imp[illegible]

[illegible] ... n, and [illegible] ... [illegible] of energy throug[illegible] ... [illegible] upper stra[illegible] of the [illegible] which [illegible] ... without [illegible] ... as I ha[illegible] ... more tha[illegible] ... dream [illegible] ... reali[illegible]

This appears [illegible] more certain[illegible] ... I found it q[illegible] practicabl[illegible] ... mit, under con[illegible]ions such as exist i[illegible] ... heights we[illegible] ... cal e[illegible] ... ergy in large [illegible]

[illegible] motors [illegible]

An Inquiry about T[illegible] ally Controlled Vessel

[illegible] have [illegible] ... to Mr. Ni[illegible] ... articles and your editorial [illegible] dated the 10th instant of yo[illegible] paper. In connection therew[illegible] mit me to inquire: Has not a serious and import[illegible] consideration [illegible] the operation of Mr. Tesla's apparat[illegible] been overlooked? [illegible] occurred [illegible] that, while the vessel is contr[illegible] [illegible]arily by means of a "coherer [illegible] receives the "waves" from the [illegible]mitter" on shore, this same [illegible] can also be influenced [illegible] "waves" set up and transmitted *fro[illegible] the vessel menaced*, and the movements of the Tesla [illegible] made uncontrollable. The Tesla vess[illegible] would, [illegible] nearer the vessel attacked, be within [illegible] stronger field of the radiati[illegible] ... atter vessel's transmitter than from the [illegible] [illegible]rolling [illegible]smitter on [illegible] where. It will [illegible] ... Tesla t[illegible] some meth[illegible] ... that [illegible] ... mitter [illegible]

Indiana[illegible]

Wonderful Ta[illegible] Stor[illegible]

From the [illegible]

Lieutenant Finley's descrip[illegible] the night he passed on Pike[illegible] [illegible]n electric snow-stor[illegible] ... que and spectac[illegible] ... ks of the storm [illegible] ... The snowflake[illegible] ... ary flakes, falling [illegible]ntl[illegible] but soon they [illegible]ged with [illegible]ectricity, and [illegible] fell on the [illegible] of the [illegible]tenant was [illegible]g it ga[illegible] out a tiny spark. The mule soo[illegible] ... darkness as if stud[illegible]

[illegible] city ... [illegible]nimously ... [illegible] electrical ... 1899 ... directors ... Kings ... Power ... Edison ... with

exclusive

[illegible]

[illegible] first com[illegible] of [illegible] the [illegible] probably [illegible] without [illegible] inventor [illegible]

[illegible] The [illegible]

[illegible] This, as no pu[illegible]

[illegible] able to [illegible] fair [illegible] Paris [illegible]

[illegible] power from [illegible] The [illegible]

[illegible] from [illegible] white light

[illegible]

[illegible] Spanish [illegible] the [illegible] war that [illegible]

[illegible] that it [illegible]

[illegible] in-
[illegible] the war too terr[illegible]
prosecuted [illegible]
drew [illegible] Tesla's mind [illegible]
time [illegible] studies which
has engaged him for years. Inspired
and fired by patriotism, he has applied
to a war engine some of the principles
which he discovered in following his
[illegible] apply-
ing energy to the purposes of peace.

The success or failure of Mr. Tesla's
[illegible] him
[illegible] which
has possessed his mind for [illegible]
This, as he puts it, is to harness the
sun's power to do the work of man-
kind. He [illegible] not [illegible]
[illegible] power [illegible] directly,
but to utilize that enormous portion
[illegible] which is expended
[illegible]

all the energy which ma[illegible]
[illegible] water-powers,
[illegible] margins, partly because of the invest-
ment cost of installment, but chiefly
[illegible] remote from the seats of [illegible]
[illegible] by [illegible]
at a remote p[illegible]
[illegible]
of current[illegible]
[illegible] water-powers
of the world, the transmittal of [illegible]

[illegible] the power from [illegible]
[illegible] would be that [illegible]
[illegible] a convenience instead of [illegible]
[illegible] water-power [illegible]
[illegible] work of the wo[illegible]

[illegible] been conducting side by side with
[illegible] in fact, leading along the
[illegible] for the means [illegible]

began his studies that a Crookes [illegible]
tube could be made to play by
passing through it currents of [illegible]
[illegible] a high-tension [illegible]
[illegible] phosphor[illegible]
[illegible] like the face of the su[illegible]
All was [illegible] Mr. Tesla to
[illegible] that the thing which [illegible]
[illegible]
[illegible] had ever been [illegible]
[illegible] and then to be able to
[illegible] control the currents [illegible]

Tesla [illegible] produce a current
with an intensity of 800,000 volts,
capable of transmission [illegible]
[illegible] for use is wait-
[illegible] reduction of the cost of
[illegible] which he says is near[illegible]

the possibilities of such [illegible]
currents as he produc[illegible]
[illegible] oscillator [illegible]
[illegible]
as a conductor [illegible]
any part of its su[illegible]
[illegible] sending [illegible]
many stations or [illegible]

[illegible] and other [illegible]
[illegible] were [illegible]
[illegible] in[illegible]
[illegible]
[illegible] itself impro[illegible]

[illegible] OF WORK.

From The Sun, New York, November [illegible]

TO THE EDITOR OF THE SUN—[illegible]
[illegible]
duties [illegible] would before this [illegible]
[illegible] editorial of November 1[illegible]
[illegible] comments and [illegible]
[illegible] ences of the hig[illegible]
[illegible] of my labors by me[illegible]
[illegible] leaders of this [illegible]
[illegible]
and I am thankful for [illegible]
[illegible] noting that [illegible]
strength and [illegible]
that those who [illegible]
have faith in me.

Permit me on this [illegible]
a few statements wh[illegible]
position in the va[illegible]
[illegible] gation you [illegible] touched [illegible]
I can not [illegible]
edge [illegible]
workers [illegible]
[illegible]

[illegible] direction, [illegible]
with complete success [illegible]
[illegible] I am producing a theor[illegible]
[illegible] able and economical light [illegible]
[illegible]
[illegible] them in use at present [illegible]
[illegible] operati[illegible]
[illegible] only su[illegible]
[illegible]
[illegible] indus[illegible]
[illegible] ted me early
[illegible] was only lo[illegible]
[illegible] rotating ma[illegible]
[illegible] hold
[illegible]
[illegible] on [illegible]
[illegible]

[illegible]WER TO AN INQUIRY CONCERNING TESLA'S LA[illegible] INVENTION

[illegible] the ELECTRICAL [illegible] last [illegible] appeared an inqu[illegible] [illegible] North, of Indian[illegible] ing [illegible] probable defec[illegible] [illegible] controlle[illegible] [illegible] by Nikola [illegible] inquired if the [illegible] [illegible] could not set up a [illegible] influence by means of similar apparatus which would be more powerful [illegible] radiation than that transmitted to the attacking vessel from [illegible] distant point where the original controlling influence was [illegible]. A number of electrical experts and the inventor himself have been [illegible] on this point, in addition [illegible] the writer of [illegible] description of the [illegible] appeared in [illegible] [illegible] this journal on [illegible] [illegible] 10. The following [illegible] [illegible] the patent, in which the italics [illegible] our own, is republished as bearing [illegible] this question.

[illegible]

[illegible] ing electrical waves of any pitch, still he would never be able to know which of the notes struck is affecting the circuit on the assailing vessel [illegible] this effect would be only momentary and speedily counteracted by the [illegible] apparatus which the ope[illegible] guiding the vessel [illegible] course [illegible] controlling [illegible]

[illegible] quite apart from the above, let it be assumed that such adjustment of the sending and [illegible] circuits was not at all observed and that [illegible] were known capable of affecting a sensi[illegible] vessel, which agent [illegible] made it impossible for the enemy to ward off the attack. The latter sup[illegible]

[illegible] any radiation propagating in straight lines, as light or short H[illegible] may be used for operat[illegible] and such radiations [illegible] off on the side towards the ene[illegible] that the latter could not affe[illegible] controlling device on the at[illegible] vessel. Still, even in such an extre[illegible] [illegible] to us that, while it mig[illegible] to disturb the [illegible] and [illegible] raphy [illegible] matter [illegible]

[illegible] how the [illegible] whereas [illegible] would have [illegible] in this respect [illegible] tell whether [illegible] apparatus, he is aid[illegible] efforts of this assailing [illegible] signals would be of [illegible] after the assailing vessel had reached a point at which

[illegible] to respond [illegible] when there might be a vessel submerged in the [illegible] responsive to his [illegible] quite [illegible] ty of expl[illegible] and [illegible] ship and [illegible] know [illegible] by his own signals [illegible] specially adapted for such pu[illegible] destruction upon him [illegible] his very efforts to [illegible] himself [illegible] larly [illegible] and all [illegible] has been [illegible] the various comme[illegible] how could a comm[illegible] possibly venture to [illegible] inquir[illegible] in the [illegible] coherer is in[illegible] [illegible] tion [illegible] of electric[illegible] suitable [illegible] scientific [illegible] Those who [illegible]

[illegible] himedes [illegible] he could [illegible] might [illegible] departure [illegible] impro[illegible] The weapon is no longer [illegible]

th welded ends, and he also heated
working cylinders to prevent
of the valves. His car oper-
and ran at
as a horse car
about all the feature
can be asserted of the
system in process of adoption
Twenty-eighth and Twenty
time, and yet we are told
brand new and will be highly

On one hand

years of alleg
it is owned by
to be f

were
elect
question
was the beginning of an
departure in the

writes that
Tesla can operate
vessel by

Befor
making such
might at least have tried to have i

another column a correspond
the ELECTRI
idea of employing electri

the electric cabs

The Genius of Destruction.

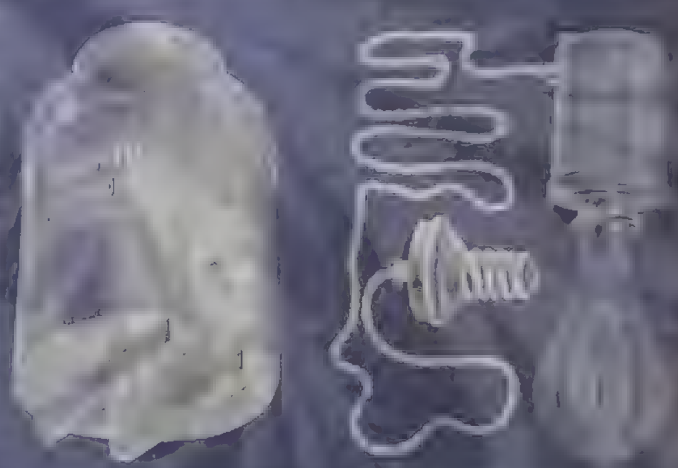
... stine ... to de- ... throughout the process of civilization ... barb-

... just made a discovery ... destruction ... one scarcely dares to contemplate ... practical results ... les in the trans- ... electrical energy ... until now ... could arouse. By simple atmos- ... without ... current ... kilometer bring ... will no ...

problem ...

structed a small model of a boat which performs all the evolutions of his pre- ... terrible in ... electric motor placed at ... in another room, controls ... movements automatically ... and on the ... electrician on board of a flag- ship seeming quite inoffensive may ... simplicity which would eclipse the knowledge of the most profound strategists, direct against the enemy ... intended to spread death around themselves—death which ... and from afar, with the ... surprise ... prepared ... man.

This is terrible and causes one to ... when contemplating ...



Figs. 1 and 2.—A Magnetic ...

... destruction brought to the ... of its terror.

... not be incredulous ... Tesla proposes ... most intellectual and ... people on earth. He in- ... at the exposition in ... of his invention. He ... direct it ... without ... electric transmi- ... for hum...

this account Nikola Tesla ... right to be called ... humanity.

Posterity will ... this claim, as well as ... have, like ... destroying ... dreaming ... that nobody ...

lightened, ... compassion ...

will ... magnanimous ... Nicholas II ... disarmament ...

[illegible] November [illegible]

[illegible] following [illegible]

from the patent, in which [illegible]

[illegible] says, in republi[illegible]

on the question [illegible]

[illegible]

[illegible] which are secured [illegible] respect, but also [illegible] being affected by [illegible] from sources not under the control [illegible] operator. The moreover the range [illegible] vibrations, which are still capable of [illegible] affecting the receiving circuit, the [illegible] the latter be against extraneous influences. To secure the best result it [illegible], as is well known to experts, to [illegible] the receiving circuit, or that part [illegible] in which the vibration chiefly [illegible] that it will have the highest [illegible] self-induction and, at the [illegible] possible resistance [illegible]

[illegible]

[illegible] kindly adjusted [illegible] be practically [illegible] only by the [illegible] to which [illegible] the vessel [illegible] difficult enough, even [illegible] make an exact adjust[illegible] such circuits alone [illegible] problem, which [illegible]

and such radiations may be screened [illegible]

[illegible] the apparatus [illegible] the efforts [illegible]

[illegible] after [illegible] had reached a point at which [illegible] signals from both the sources [illegible] of equal intensity. Now [illegible] quite easy, in our opinion, for the [illegible] controlling the course [illegible] vessel and the operation of [illegible] on board of the same [illegible] straight upon the enemy, put the machines at top speed, release the exploding mechanism and render all further signals inactive. Since [illegible] vessel can carry any amount of [illegible] plosive, it would not be necessary to come very close to the enemy to [illegible] his destruction.

How about the intensity of the sig[illegible] Can the signals from a man-of-war be made as strong as from a vessel especially fitted for this purpose? Would it be advisable to have such a powerful apparatus on [illegible] of a warship when the experts tell us that powerful electrical vibrations [illegible] apt to make large sparks about in any part of the structure [illegible] liable to short-c[illegible] and injure any of the [illegible] electrical apparatus on board, and, worst of all, inflame the stores of explosives? Would any commander undertake the responsibility of operating such a powerful apparatus on board of his ship under such condi[illegible]

Now it is not difficult to employ on [illegible]

[illegible] to utilize the [illegible] [illegible] and utilizing fee[illegible] well known to scienti[illegible]

[illegible] around [illegible] carrying out [illegible] invention [illegible] not limited to any particular mode of signaling, and on this [illegible] Tesla expresses himself clearly [illegible] the following [illegible]

[illegible] carrying [illegible] oscillations [illegible] through space, [illegible] disturbances [illegible] the mechani[illegible] action [illegible] operator, by their [illegible] controlling devices [illegible] signaling without [illegible] or other [illegible] ancient—whereas [illegible] have before stated, has created an art entirely novel, for there never was such a thing as guiding the movements of a distant body and controlling all of its appliances without any artificial connection whatever.

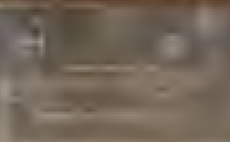
It is, perhaps, astonishing that this epochal idea has not been evolved in times long past, for it would seem that it might have been carried into effect, without the use of any electrical means whatever, by some mean[illegible]

[illegible] observation that currents are prop[illegible]

[illegible] well known among telephone [illegible] having been engaged [illegible] the Bell license companies [illegible] with the New Y[illegible] he was connected with the ri[illegible] had [illegible]

ing no part,
nt that the

[illegible]



[illegible]

high frequency and

to be necessary

arcely more than 20 kilometers thick

...ing Mr. J. D. ...
sent a paper on ...
Primary Batt...
will be a special m...
trical Section...
Washington, Jr., ...
... Water-Power ...
in the United Stat...
lantern slides.


Arc Lighting ...

dinner in his home ...
laborate affair. ...
number of interesting d...

A Modest ...

To the Editor of ...

Dear Sir: Pl...
...rmation you can ...
Will electricity ...
the horse ?

banquet-hall for the oc

experiments did not begin

[illegible]

[illegible]

[illegible] LEPHO [illegible]

tect by electric mines and torpedo our [illegible] line and harborage [illegible] for [illegible] the U. S. Military [illegible]

[illegible]

T[illegible] of agriculture by electricity. Last week we noted [illegible] obtained on a farm in Germany, [illegible] farmers using the telephone [illegible] their operations, experiments at agricultural stations with kinds of current in stimulating [illegible] [illegible] factory or the farm is to be the new scene of electricity's next triumphs.

It will be remembered that not long ago, Mr. Tesla suggested that part of the energy of powers like that of Niagara might be applied to furnishing nitrogenous elements to the [illegible] so that better crops could be secured. This may explain [illegible] Mr. S. S. Harvey in the South wrote to him [illegible] could not be used in a general pervasive way [illegible] the bugs that are such a pest in orchards and vine[illegible] Mr. Tesla, with wonted courtesy, admitted the im[illegible] of the subject and said in response to the inquiry [illegible] that we can destroy these detrimental insects in certain ways by the help of electricity, but to what extent the trees would be affected by the application of these means I do not know, and it can only be settled [illegible] series of ex[illegible] I have some ideas on the subject, and think that [illegible] be produced in a short [illegible] I am resolved to think over the matter in the hope to [illegible] of some tangible [illegible]

We have no doubt [illegible] people the idea [illegible] electrical inventor [illegible] time to [illegible]

[illegible]ICAL ENGINEER

and "sure de[illegible] ious; but in reality [illegible] of more real and practica[illegible] no de[illegible]

[illegible]

I[illegible] surgeon a pow[illegible] ateur a new and attra[illegible] perfect as the mecha[illegible] [illegible] has been made [illegible] bring out the desired form of rays. The [illegible] accompanied by and has [illegible]

The Electrical Engineer Feb. 3, 1897 pp. 140 141

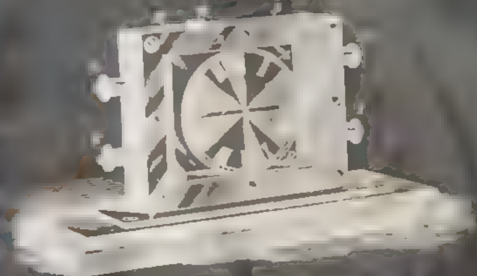
MR. TESLA'S VIEWS ON THE FUTURE OF ELECTRICITY

THE inauguration of the Buffalo [illegible] brought [illegible] sentative gathering of influential men and [illegible] of memorable addresses. Of the speeches devoted to [illegible] ical side, that of Mr. Tesla's deserves more than [illegible] as containing the expression of his latest [illegible] on subjects which he has made his special [illegible] for some time past. Speaking of the types of pri[illegible] in use to-day, Mr. Tesla gives no encouragement for [illegible] of the reciprocating high speed engine in its p[illegible] nor for the steam turbine. His ideal engine is on[illegible] pands the working fluid with utmost rapidity and loses little heat in the walls; an engine stripped of all usual regulating mechanism, packings, oilers and other appendages and forming part of an electric generator. Mr. Tesla, though not mentioning it by name, here evidently referred to his oscillator brought out in 1893. As to the outlook for a carbon consuming battery, Mr. Tesla does not consider it over-promising, viewed from the standpoint of a source of power. T[illegible] ibility of replacing the engine-dynamos by batteries is, i[illegible] Tesla's opinion, a remote one, the more so as the high [illegible] sure steam engine and the gas engine give promise of a considerably more economical conversion. Mr. Tesla also sees drawbacks lurking in the fact that carbon to be consumed in batteries has to be prepared for that purpose and cannot be [illegible] as found, as it is under the boiler. The manipulation [illegible] cleaning, renewal, regulation, etc. of the batteries, and their [illegible] together with the character of the liquids employed in [illegible] would make it difficult, if not unprofitable, to handle such a plant in a densely populated city district. While thus expressing little faith in the carbon battery, Mr. Tesla has hopes for the ultimate supply of isolated plants or dwellings in the development of what he calls a light "storage battery," involving the use of chemicals manufactured by cheap water power, such as some carbide or oxy-hydrogen cell. We incline to the opinion that what Mr. Tesla has in mind partakes more of the nature of a primary gas batt[illegible]

But it is Mr. Tesla's conclusions on the results of his own particular work which will perhaps command the greatest attention among electrical engineers and the public at large. It will be recalled that in his very first lecture at Columbia University in 1891 he threw out the suggestion that it might be possible to operate engines at any point on the earth "by the energy of the medium." Six years of continued study have brought him beyond the stage of mere conviction, and he now feels sure that the realization of his ideas is not far off. But at the same time Mr. Tesla confesses the disappointing conclusion reached by him that under the theoretically best conditions such a method of obtaining power cannot equal in economy, simplicity and many other features the present method of converting the energy of falling water into electric current, and transmitting it over long distances at high potential. With this conviction of the greater utility of water power, Mr. Tesla has bent his energies to the means of transmitting it, and now informs us that he has devised means which permit of power transmission at potentials much higher than are now considered practical. He hints further that the progress he has made gives him fresh hope that he will be able to transmit power from station to station without the [illegible]

If a delicately pivoted [illegible] well-balanced metal disc or cylinder be placed in a proper plating solution midway between the anode and cathode, one half of the disc becomes electro positive and the other half electro negative. Owing to this fact metal is deposited on one, and taken off from the other half, and the disc is caused to rotate under the action of gravity. As the amount of metal deposited and taken off is proportionate to the current strength, the speed of rotation, if it be small, is proportionate to the current.

The first device of this kind was operated by me early in 1888, in the endeavor to construct an electric meter. Upon learning, however, that I had been anticipated by others, as far as the principle is concerned, I devised the apparatus illustrated in the accompanying engraving. Here F is a rectangular frame of hard rubber which is fastened upon a wooden base. This frame is about ½ inch thick, 6 inches long and 5 inches high. On both of its upright sides are fastened thick metal plates which serve as the electrodes. These plates are held firmly against the rubber frame by the binding [illegible] and [illegible]. On the [illegible] of the frame are [illegible] and B, respectively, of the same shape [illegible] frame F. These brass plates serve to keep in place two plates of



Tesla's Electrolytic Clock.

polished glass, and the vessel is hermetically sealed by placing a soft rubber washer under and above each of the glass plates. In this manner the plates may be screwed on tight without fear of breaking them.

The plating solution, which in this case is [illegible] solution of sulphate of copper, is poured in through an opening on the top of the rubber frame, which is closed by a [illegible].

In the [illegible] of the vessel is placed a light [illegible] copper disc D, the axis of which is supported by a capillary glass tube [illegible] of the glass plates [illegible] other material not attacked by the liquid. To diminish the friction as much as possible, the capillary tube [illegible] bearing [illegible] drop of oil. The [illegible] should be equidistant from both the [illegible] side of the axis of the disc is fastened a [illegible] or pointer consisting preferably of a [illegible]. The glass plate next to this pointer has [illegible] with the usual hour divisions engraved upon it, as on a clock dial. This circle may [illegible] relatively [illegible]

should then be so placed that it is exactly in the [illegible] the solution. By means of a horse-shoe [illegible] may then be rotated and set in proper [illegible].

The copper solution being [illegible] is replaced, the terminals [illegible] are connected to the [illegible] ing the resistance of this shunt, [illegible] rotation is regulated until it is [illegible] division of the dial; that is, until, for instance, [illegible] made in 12 hours.

Obviously this instrument was not devised for a practical purpose. Neither will it be quite exact in its indications. There are certain errors, unavoidable from the principle; for instance, the friction, which cannot be completely overcome. But the device is interesting as a means [illegible] time in a novel manner. It will, however, be found that [illegible] rent, and a temperature com[illegible] with almost perfect [illegible] to secure the best re[illegible] should, of course, be very small [illegible] diameter should [illegible] of about [illegible] inches [illegible] that with a silver solution [illegible] would be obtained.

[illegible] and a silver [illegible] the solu[illegible] it is very [illegible]. The [illegible] tion and disc in [illegible] solution appears a clear blue, one side of [illegible] and the other half is [illegible]

OPERATING SUB-STATIONS BY THE MOTOR-DYNAMO SYSTEM IN BROOKLYN.

The Edison Electric Illuminating Company of Brooklyn, during the fall of 1890, [illegible] to extend their territory [illegible] furnishing low tension [illegible] by the erection of a second district station. After a [illegible] consideration of the matter, it was deemed best to supply this new territory from their present first district station until a sufficient load was accumulated to warrant the [illegible] necessary for the erection and maintenance of [illegible] district station. For this purpose a large feeder, consisting of copper conductors of 1,000,000 circ. mils each, was laid underground to a point two miles distant from the present first district station. From this point sub-feeders were laid, and these in turn were heavily bridged by the net-work of mains. A standard feeder is selected from one of these sub-feeders, and at the extremity of this the voltage is kept at a constant pressure. As the load increases, the voltage is necessarily raised at the station end of the large feeder so as to preserve the voltage at the extremity of the sub-feeder. The efficiency of this system of low tension long distance transmission depends on the cost of the loss in the main feeder compared with the increased operating expenses of a second district station. When the cost of the loss (in watts) in this transmission equals the operating expenses of a second district plant, then this plant will be erected and will be run until the cost of operating exceeds the loss in transmitting from the first district station. It has been theoretically calculated (and since proved by practical results) that 1,000 amperes can be transmitted before the starting of the new station is

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Many valuable inventions have been founded on the discovery of simple facts, but such inventions can never be perfected unless the principles of science upon which they are based are known.—Joseph Henry.

THE TESLA EXPERIMENTS.

WHILE the interest in all the papers of the annual meeting of the American Institute of Electrical Engineers was sustained throughout the sessions, there can be no question that most interest centred upon the lecture delivered by Mr. Tesla on the phenomena of alternating currents of high frequency. Mr. Tesla's recent utterances on this subject had served to excite the curiosity of many, and we believe that a thorough analysis of the work accomplished by Mr. Tesla, as exhibited in the experiments shown by him, will lead to the conclusion that those expectations have been more than realized. The brilliant researches and experiments inaugurated by Dr. Hertz, and followed up by Lodge and others, which served to verify the theory that the phenomena of light were referable to electro-magnetic vibrations of the ether, seemed to point out an apparently easy way of obtaining illumination directly through the medium of electro-magnetic vibrations. It has remained for Mr. Tesla, however, to recognize that for the production of light, electrostatic effects are needed. He reasoned that it was impossible to obtain primarily the desired electro-magnetic effects, since we must work with bodies of infinitesimal dimensions which can be acted upon only electrostatically, it being evident that an electro-magnetic wave cannot excite luminous radiation unless it be a true light wave. To produce longer electro-magnetic waves would, therefore, be of no avail; but this is not the [illegible] with electrostatic waves or thrusts. These, no matter [illegible] charges, [illegible] emit light; and since electrostatic [illegible] upon the conjoint effects of potential [illegible] reasoning led him to the investigations, the results of which were shown.

Continuing the train of reasoning followed by Mr. Tesla, we see that he has recognized further, that electrostatic effects of such character are available in many ways for the production of light. Thus he showed that if a filament [illegible] source, in consequence of the rapidly alternating potential, [illegible] and in this manner by their impact a filament may be kept at incandescence with only one wire. With these facts before him, and recognizing further that the employment of a filament is a bar to the attainment of higher efficiency [illegible] globe and sufficient energy transferred by condenser action to keep the blocks at incandescence, thus allowing a much higher efficiency in the production of light by reason of the possibility thus [illegible] Mr. Tesla has also shown [illegible] ment placed in a [illegible] globe and [illegible] desired incandescence. Another and most important fact which he demonstrated was the practicability of using tubes of rarified gas [illegible] terminals as practical sources of illumination [illegible] near them, and [illegible] wires. All these results can evidently only be obtained by the use of enormous frequencies and potentials, or, in other words, powerful electrostatic effects, the study of which was made difficult in consequence of the fact that in previous experiments, looking to [illegible] the static effects were excessively small, owing to the fact that the coil was short circuited through the low resistance discharge between the knobs of the discharger. The method of conversion devised by Mr. Tesla, allowing of the use of any frequency, enables us to undertake a much more exact and easy study of the effects of short waves. Again, his experiments with the lamps burning when connected with their terminals to a short, thick copper bar, are extremely interesting. The possibility of verifying nodes on the bar by simply using a Cardew voltmeter, will be of great value in investigating these phenomena. His experiments also prove that while, with alternating currents of low frequency, such as are now generally employed, the effects of self-induction must be largely considered, those of high frequency accentuate largely the condenser effects which have to be allowed for accordingly.

It would lead us too far to enter into all of the numerous points suggested by Mr. Tesla's lecture, but he showed enough to warrant the assertion that in a comparatively short time the practical application of these principles to the production of artificial illumination will be an accomplished fact.

TESLA'S EXPERIMENTS WITH ALTERNATING CURRENTS OF HIGH FREQUENCY.

THE Wednesday evening session of the American Institute of Electrical Engineers was held in Prof. Dwight's room, Columbia College, and will long be remembered by those present, not only on account of the brilliant experiments shown, but also for the [illegible] which it [illegible] artificial illumination of the future. For the purpose of his experiments, Mr. Tesla employed the alternating machine with 384 poles, described in THE ELECTRICAL ENGINEER of March 18, 1891, which, when run at full speed, permitted him to obtain 20,000 alternations per second. The currents of this machine in all of Mr. Tesla's experiments were first run through a condenser in order to avoid the possibility of injury to the machine. The machine itself was set up in the electrical workshop of the college and was driven by an electric motor, the speed of which could be varied by a switch on the lecture platform.

Mr. Tesla introduced his subject by the remark that modern science has been able to make rapid strides by the recognition of [illegible] of transmission of vibrations of various [illegible] which [illegible] themselves to our senses. We are therefore now able to see things in a [illegible] [illegible] [illegible] [illegible] [illegible] Electricity [illegible] [illegible] [illegible] justified in assuming, however, [illegible] [illegible] phenomena, and [illegible] [illegible] [illegible] as phenomena of [illegible] under [illegible] [illegible]

Mr. Tesla, while expressing the highest consideration for the work of Dr. Lodge, was not in entire accord with the views advanced by him, which he considered to be more of the nature of ingenious explanations than of a probable theory, Mr. Tesla contending that there can be no two electricities.

Alluding further to the electro-magnetic theory of light, and to the Hertz experiments and those of Dr. [illegible] and their application to the production of an efficient source of light, Mr. Tesla considered the electro-magnetic waves as unavailable for the production of luminous effects, for the reason that long before we could reach the necessary frequency the conductor would become opaque to the passage of the waves. Mr. Tesla thought that electro-magnetic waves, unless they have the frequency of true light waves, cannot produce luminous effects. Not so, however, with the electrostatic waves or thrusts. These, no matter what their frequency, can excite luminous radiation. He reasoned that the static effects in the Hertz and Lodge experiments were excessively small, due to the fact that they were produced in a practically closed coil, the spark acting as a bridge, making the coil practically continuous and depressing the potential. To obtain the desired difference of potential we must work with an open circuit generator of high potential of high frequency to enhance the electrostatic effects, and it was the recognition of this fact which led Mr. Tesla to the results he showed.

In carrying out this idea of obtaining enormous differences of potential, Mr. Tesla at once encountered the difficulty of obtaining the requisite insulation for the induction coil employed by him. His experience demonstrated that what we consider the best insulators, such as glass and rubber are inferior to others, not formerly so considered, such as oil and wax. Mr. Tesla then started a spark coil in action, the primary of which was in connection with his alternator which was speeded to give from 10,000 to 11,000 alternations per second. The coil emitted a clear note, which rose as the number of alternations was increased. As the discharge took place between the terminals of the coil, an exhausted Geissler tube held in proximity to the discharge did not light, but upon blowing out the arc the tube lighted up, which was due to [illegible] of potential caused by the rupture of the [illegible]. This [illegible] [illegible] considered as purely electrostatic.

Mr. Tesla then showed the influence of insulated bodies having considerable size upon the spark length, demonstrating the effect of capacity upon the nature of the discharge. Thus when we attach an insulated body to the terminal of the coil, the potential may be raised or lowered. He showed this by wrapping an insulated wire of about one foot in length about one terminal of the coil, and touching the other terminal with a brass sphere held in the hand; under these conditions streams of light emanated from all sides of the wire. When the sphere was removed, however, the streams disappeared almost entirely. He then cut off the wire in successive lengths, and the stream discharges became more marked and brilliant. He then attached a fine platinum wire to the terminal, which also showed the streams to a remarkable degree, and kept up a continuous vibration to and fro. He also showed a pinwheel effect, the wheel being rapidly rotated with streams issuing from the two points. Another experiment consisted in [illegible] two spheres of about four inches diameter to [illegible] tons, is extinguished and is re-established at the [illegible] being continuously repeated. The neighbouring [illegible] lamps were illuminated and extinguished [illegible] with [illegible] tion of the spark between the spheres. These Mr. Tesla pointed out were not electro-magnetic vibrations [illegible] Hertz. He showed how by the use of the dielectric [illegible] between the separated spheres, due to [illegible] [illegible] medium, and he also [illegible] [illegible] passed easily through thick glass plates, rubber plates and a book. Mr. Tesla then showed these static effects in a non-striking vacuum. A tube of this nature when connected to the machine glowed brightly, and the terminals became incandescent. Mr. Tesla then remarked that if, instead of using a filament in a lamp—which necessarily limited us in the degree of incandescence which we could practically [illegible]—we could employ solid blocks of carbon, much higher [illegible] ency could be obtained. Based upon this reasoning, he had constructed a lamp which he showed, containing two blocks of carbon in a non-striking vacuum. When connecting these two carbons to the two terminals of the coil or one to one terminal and the other to a body of [illegible] size, the blocks can be raised to high incandescence.

Mr. Tesla also showed a lamp with but a single [illegible] in a non-striking vacuum [illegible] [illegible] [illegible] [illegible] altering the relative position of the condenser [illegible]

Mr. Tesla followed by demonstration of the phenomena with an unexhausted globe, and a single filament mounted [illegible]. The filament when connected to one terminal of the coil [illegible] up to bright incandescence [illegible] [illegible]. He also demonstrated the heating by the use of [illegible] well-known apparatus consisting of mica vanes mounted above a platinum wire, which was brought to incandescence by connection with one terminal of the coil, and rotated the mica vanes.

[illegible] static effects are alone active, Mr. Tesla placed a Geissler tube at [illegible] [illegible] the tube did not light up. When placed at the ends, however, the tube lit up brilliantly and gave sufficient light to read [illegible]. Mr. Tesla showed both uranium and yttria tubes.

He then showed how exhausted tubes could be made to glow in an electrostatic field. For this purpose two large sheets of zinc were connected to the terminals of the machine at a distance of about 15 feet apart. The tube when placed between these sheets glowed brilliantly and could be moved about freely. Mr. Tesla remarked that, by merely creating such a field in a room, the mere suspension of the tubes in the room would afford the desired illumination.

Coming to the physiological effects, Mr. Tesla adjusted the conditions so that by touching one terminal with a brass sphere he raised the potential of the coil so enormously that a stream of light came out on the other terminal, and he estimated the difference of potential to be nearly 250,000 volts, and then performed the remarkable experiment of receiving the total discharge through his body, protecting his hands from burning by the brass balls held in his hands.

He then lit up lamps by holding them in contact with one terminal or near to the coil.

The lecturer then came to another class of experiments. He stated that he had used a system of conversion from high tension to low with the enormous frequencies of the condenser discharges. Mr. Tesla then showed an interesting experiment which consisted in passing the converted currents, produced in the manner just described, through a copper bar [illegible] inch in diameter and bent into a loop. Ordinarily such a bar would constitute a short circuit, but Mr. Tesla succeeded in bringing lamps stretched across the parallel sides of the bar to incandescence, demonstrating that the impedance in the loop connecting the two sides was so great as to practically prevent the current from passing through it and hence [illegible] upon the lamps in the manner described. He also pointed out the existence of nodes on the bar. His method consists in continuously charging and disruptively discharging a condenser into the working circuit, the charging of the condenser being effected by a coil operated either by alternating or direct currents. By this means any desired higher frequency may be obtained from any lower frequency.

Mr. Tesla concluded his experiments by exhibiting in action a simple alternate current arc lamp, operated by currents direct from the machine giving 20,000 alternations per second. The light was beautifully steady and the arc entirely free from the hum accompanying arcs operated with currents of low frequency.

We have given but the merest outline of the many beautiful and highly suggestive experiments made by Mr. Tesla. Notwithstanding the fact that Mr. Tesla excited the intensest interest of his audience for three hours, he was nevertheless unable, for lack of time, to bring before them [illegible] experiments, some of which, [illegible]

PHYSIOLOGICAL AND OTHER EFFECTS OF HIGH FREQUENCY CURRENTS.

BY

Nikola Tesla

IN THE ELECTRICAL ENGINEER of January 25, 1893, I note an article by Mr. A. A. C. Swinton, referring to my experiments with high frequency currents. Mr. Swinton used in these experiments the method of converting described by me in my paper before the American Institute of Electrical Engineers, in May, 1891, and published in THE ELECTRICAL ENGINEER of July 8, 1891, which has since been employed by a number of experimenters; but he [illegible] makes use of an [illegible] vibrating contact-breaker, whereas he could have employed a much simpler method of converting continuous currents into alternating currents of any frequency which was shown by me two years ago. This method does not involve the employment of any moving parts, and allows the experimenter to vary the frequency at will by simple adjustments. I had thought that most electricians were at present familiar with this mode of conversion which possesses many beautiful features.

The effects observed by Mr. Swinton are not new to me and [illegible] by those who have [illegible] read what I have written on the subject. But I cannot agree with some of the views expressed by him.

First of all, in regard to the physiological effects. I have made a clear statement at the beginning of my published studies, and my subsequent experience with these currents has only further strengthened me in the opinion then expressed. I stated in my paper, before mentioned, that it is an undeniable fact that currents of very high frequency are less injurious than the low frequency currents, but I have also taken care to prevent the idea from gaining ground that these currents are absolutely harmless, as will be evident from the following quotation: "If received directly from a machine or from a secondary of low resistance, they (high frequency currents) produce more or less powerful effects, and may cause serious injury, especially when used in conjunction with condensers." This refers to currents of ordinary potential differences such as are used in general commercial [illegible].

As regards [illegible] very high potential differences [illegible] in my experiments, I have never considered [illegible] the energy which the human body w[illegible] without injury, and I have expressed the [illegible]. For instance, I stated [illegible] the frequency [illegible] greater the amount of energy which may be passed through the body without discomfort." And on another occasion [illegible] was short-circuited though the body of the experimenter [illegible] that the immunity was due to the fact that less [illegible] available externally to the coil when the experimenter's body joined the terminals. This is practically what Mr. [illegible] by saying that with [illegible] frequency [illegible] exceedingly small currents," etc.

[illegible] with [illegible] have expressed [illegible] equal [illegible] some phenomena of impedance which at that time (1891) were considered very striking, and I have also pointed out the great importance of the rarefied gas surrounding the filament when we have to deal with currents of such high frequency. The heating [illegible] filament by comparatively small currents is not, as Mr. [illegible] thinks, due to the impedance or increased ohmic resistance, but principally to the presence of rarefied gas in the bulb. Ample evidence of [illegible] of this can be obtained in very many experiments, and to cite them would be merely lengthening this communication unduly.

Likewise, observations made when the experimenter's body is included in the path of the discharge, are, in my opinion, not [illegible], but capacity, phenomena. The spark between the [illegible] is the shorter, the larger the surface of the body, and no [illegible] whatever would be obtained if the surface of the body [illegible] sufficiently large.

I would here point out that one is apt to fall into the error of supposing that the spark which is produced between two points on a [illegible] distant from each other, is due to the [illegible] conductor. This is certainly the case when the [illegible] considerable strength, as for instance when, like in [illegible] experiment or some of Dr. Lodge's, a heavily charged battery of Leyden jars is discharged through a bent wire. But, when there is a vibration along a wire which is constantly maintained, and the current is inappreciable whereas the potential at the coil terminal is exceedingly high, then lateral dissipation comes into play prominently. There is then, owing to this dissipation, a rapid fall of potential along the wire and high potential differences may exist between points only a short distance apart. This is of course not to be confounded with those differences of potential observed between points when there are fixed waves with ventral and nodal points maintained on a conductor. The lateral dissipation, and not the skin effect, is, I think, the reason why so great an amount of energy may be passed into the body of a person without causing discomfort.

It always affords me great pleasure to note, that something which I have suggested is being employed for some instructive or practical purpose; but I may be pardoned for mentioning that other observations made by Mr. Swinton, and by other experimenters, have recently been brought forward as novel, and arrangements of apparatus which I have suggested have been used repeatedly by some who apparently are in complete ignorance of what I have done in this direction.

ELECTRICAL RECORDING METERS.—II.

BY CARYL D. HASKINS.

There is another device, or perhaps [illegible] be another device for accomplishing the object of this last meter in a somewhat [illegible] manner. The actinometer is probably [illegible]

ons practically acquainted with them are ...
rejected manuscripts will be returned ...

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pay, or in consideration of advertising patronage, ...
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VOL. XV. NEW YORK, J...

MR. TESLA'S HIGH FREQUE...

IT is now nearly a year since Mr. Nikola ...
brilliant demonstrations here, scored such decided
umphs in the lectures which he delivered abroad at the i
tation of various scientific societies; yet the interest wh
is manifested in his recent work not only by electri...
by many laymen, is such as to make highly welcome
publication of the abstract of Mr. Tesla's lecture, prep
by him for, and just published in, the Transactions of
Royal Institution of England. In this abstra... Mr. T
gives a succinct account of the reasonings and experim
which led up to the results obtained by him, and, ...
altogether, they present a remarkable array of experim...
facts in a field entirely new. Although replete with f
and suggestions, many of them quite new, it must be
dent that the paper embodies but a tithe of Mr. Te
work in this field, the complete record of which would
more than one volume of surpassing interest. Those
attend the convention of the National Electric Light As
ation in St. Louis, next month, will have an opportunit
witnessing some of Mr. Tesla's experiments in a lec
which he has consented to deliver before the Associa

EMANCIPATING THE CANAL MULE.

IN his message to the Legislature, Governor ...
New York, ... that only steam canal-boats capab

[illegible] with the [illegible] perceptible smile.

"Yes," I replied "and in the course of an hour's chat with him he spoke about you."

"Mr. Gould became at once interested, and said: "Well, what did he say?" I repeated the words above quoted. He looked in at the tomb of Lawrence of "never give up the ship" fame just inside the church railings. Two o'clock in the afternoon; Broadway was thronged. Looking up suddenly, he saw that fifteen or twenty people had stopped to look at him. His pallid face flushed a little, and he said: "Will you walk down to the office with me?" It was only a few steps away. I then told him about the Wolseley incident, and what Mr. Pender had said [illegible] Union, which seemed to gratify him very much."

ALTERNATE CURRENTS OF HIGH POTENTIAL AND HIGH FREQUENCY.[1]—I.

BY NIKOLA TESLA.

At the first outset this investigation was taken up with the view of studying the effects of rapidly changing electrostatic and electromagnetic stresses. It was thought, from theoretical considerations, that some useful observations would be made in following up this line of experiment by means of properly constructed apparatus; but the anticipations were by far surpassed, for a number of unexpected phenomena were noted, and some novel facts brought to light, which have opened up a new and promising field of research. Some of the results obtained are of special interest on account of their direct bearing upon the problem of producing an efficient illuminant.

The phenomena which are due to the changing character of the stresses are realized when the time rate of change is increased, hence the study of these phenomena is much facilitated by the [illegible] of apparatus adapted especially for the purpose of [illegible] on such investigations. With this object in view, several types of alternators were constructed, capable of giving currents of frequencies from 5 to 10,000 and even more. Currents of much [illegible] frequencies used in some of these experiments were obtained by disruptively discharging condensers.

The construction of the alternators offered at first great difficulties. To obtain these frequencies it was necessary to provide several hundred polar projections, which were necessarily small and offered many drawbacks, and this the more, as exceedingly [illegible] speeds had to be resorted to. In some of the first machines both armature and field had polar projections. These machines produced a curious noise, especially when the armature was started from the state of rest, the field being charged. The most efficient machine was found to be one with a drum armature, the iron body of which consisted of very thin wire annealed with special care. It was, of course, desirable to avoid the employment of iron in the armature, and several machines of this [illegible] with moving or stationary conductors were constructed, but the results obtained were not quite satisfactory, on account of the [illegible] mechanical and other difficulties encountered.

The study of the properties of the high frequency currents obtained from these machines is very interesting, as nearly every experiment discloses something new. Two coils traversed by such a current attract or repel each other with a force which, owing to the imperfection of our sense of touch, seems continuous. An observation, scarcely foreseen, is that a piece of iron, surrounded by a coil through which the current is passing appears to be continuously magnetized. This apparent continuity [illegible] in currents of such high frequencies [illegible] over the other. As might be expected [illegible] by such currents are rapidly heated, [illegible] resistance, and the heating [illegible] are [illegible]

The hysteresis [illegible] iron are so great that [illegible] finely subdivided, is heated in an incredibly [illegible] an ordinary iron wire of [illegible] within a coil having [illegible] turns, with [illegible]

[1] [illegible] before The Royal Institution [illegible]

inside the church railings. Two o'clock in the aftern
way was thronged. Looking up suddenly, he saw th
twenty people had stopped to look at him. His pallid
a little, and he said: "Will you walk down to the
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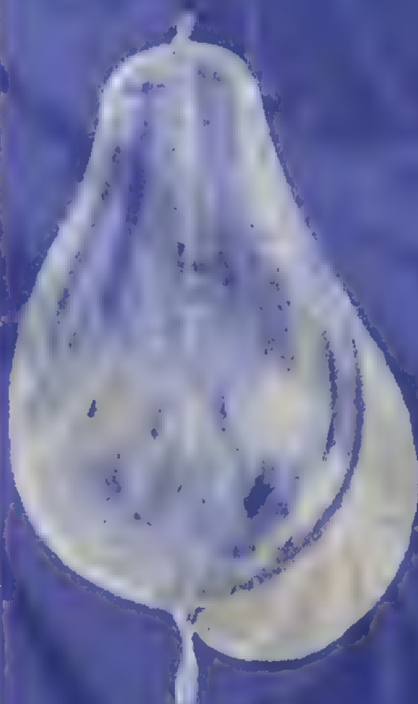
ALTERNATE CURRENTS OF HIGH POTEN HIGH FREQUENCY.[1]—I.

BY NIKOLA TESLA.



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culties. To obtain [illegible]
several hundred [illegible]
and offered many [illegible]
high peripheral speeds [illegible]

The Cataract Construction Company has already sunk a shaft sufficient to accomodate three of the 5,000 h. p. turbines which are to be used for the work of distributing light and power. Con[illegible] making [illegible] by the in-flux of water through a seam at a depth of about [illegible] feet below the surface. These difficulties have never interfered with the pr[illegible]gress of the work, which has now been successfully carried out. The turbines which are to be used are of 5,000 h. p., revolving at 250 revolutions per minute, of the Girard or impulse type, with a regulator for adjusting the flow of water. Each turbine is double. Attached to the shafts of the turbines are vertical shafts, extending to the surface of the ground, and, on the top of these shafts the dynamos are to be mounted, which will transmit electri[illegible] for light and power purposes, to the surrounding distric[illegible] [illegible] from the designs of Messrs. [illegible] Piccard, of Geneva, who transmitted the working drawings to America; and the contract for these turbines has now [illegible] out to the I. P. Morris Company, of Philadelphia, two tur[illegible] having been ordered in the first instance. Twenty of these [illegible] be required to utilize the full capacity of the tunnel, [illegible] 100,000 h. p. (See diagram on page 64

ALTERNATE CURRENTS OF HIGH POTENTIAL AND HIGH FREQUENCY.[illegible]

BY NIKOLA TESLA.

In operating an induction coil with these rapidly alternating currents [illegible] astonishing to note, for the first tim[illegible] great importance of the relation [illegible] capacity, self-induction, and frequen[illegible] as regards the general result. The [illegible]bination of these elements produces [illegible] curious effects. For instance, two meta[illegible] plates are connected to the terminals and set at a small distance, so that an [illegible] formed between them. This arc preven[illegible] a strong current to flow through the coi[illegible] If the arc be interrupted by the in[illegible]position of a glass plate, the capacit[illegible] the condenser obtained countera[illegible] self-induction, and a stronger current is made to pass. The effects of ca[illegible] [illegible] the most [illegible] [illegible]ments, since the self-induction, and frequency both are high, the critical capacity is very small, and need be but slightly varied to produce a very considerable change. The experimenter brings his body in contact with the terminals of the secondary of the coil, or attaches to one or both terminals i[illegible]ated bodies of very small bulk, such as exhausted bulbs, and produces a considerable rise or fall of potential on the secondary [illegible] coil.

In many of the phenomena observed, the presence of th[illegible] generally speaking, of a medium of a gaseous nature (using [illegible] not to imply specific properties, but in contradistinction [illegible] homogeneity or perfect continuity) plays an important part [illegible] energy to be dissipated by molecular impact [illegible] The action is thus explained[illegible]

When an insulated body connected to [illegible] suddenly charged to a high potential, it acts inductively [illegible] surrounding air, or whatever gaseous medium there might [illegible] The molecules or atoms which are near it are, of course, more [illegible]tracted, and move through a greater distance than th[illegible] ones. When the nearest molecules strike the body they [illegible]pelled, and collisions occur at all distances within the [illegible] distances. It is now clear that, if the potential be st[illegible] little loss of energy can be caused in this way, for th[illegible] which are nearest to the body having had an add[illegible] imparted to them by contact, and not attracted u[illegible] parted, if not with all, at least with most of the additional [illegible] which can be accomplished only after a great many colli[illegible] This is inferred from the fact that with a steady poten[illegible] but little loss in dry air. When the potential, instead of steady, is alternating, the conditions are entirely different. In this case a rhythmical bombardment occurs, no matter whether the molecules after coming in contact with the body lose the imparted charge or not, and, what is more, if the charge is not [illegible] impacts are only the more violent. Still, if the frequ[illegible]

the dynamos are to be mounted, which will transm
for light and power purposes, to the surrounding di
Buffalo. The turbines are from the designs of Messr
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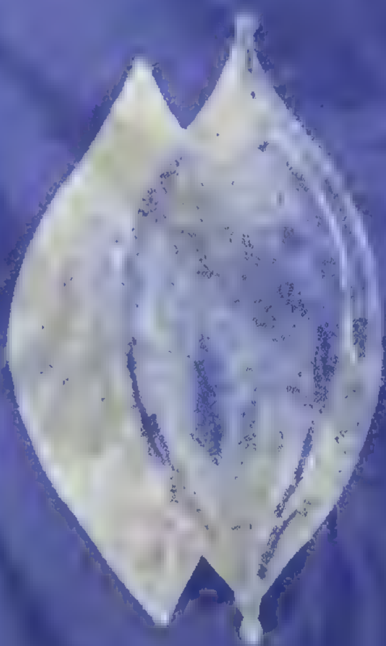
100,000 h. p. (See diagram on page 64.)

ALTERNATE CURRENTS OF HIGH POTE HIGH FREQUENCY.—II

BY NIKOLA TESLA.



In operating an induc these rapidly alternating astonishing to note, for the great importance of th capacity, self-induction, a as regards the general test bination of these elements p curious effects. For insta plates are connected to the set at a small distance, so formed between them. Th a strong current to flow th If the arc be interrupted position of a glass plate t the condenser obtained c self-induction, and a stro is made to pass. The effec are the most striking, for h ments, since the self-indu quency both are high, the critical capacity is very s be but slightly varied to produce a very considerable experimenter brings his body in contact with the te secondary of the coil, or attaches to one or both te ated bodies of very small bulk, such as exhausted produces a considerable rise or fall of potential on t and greatly affects the flow of the current through coil.

In many of the phenomena observed, the presence generally speaking, of a medium of a gaseous nature (not to imply specific properties, but as contradistin geneity or perfect continuity, plays an important p energy to be dissipated by molecular ...

EXPERIMENTS WITH HIGH FREQUENCY ELECTRIC DISCHARGES.

BY

[illegible]

The [illegible] passing [illegible] the body from hand to hand sufficient electricity to bring the filament of an ordinary [illegible] incandescent lamp very nearly to full incandescence, or to bring the filament of a 32 c. p. 100 volt lamp to dull redness. Practically no sensation was experienced.

The apparatus employed consisted of a large "Apps" induction coil capable of giving 10" sparks, supplied with current through the ordinary vibrating contact breaker and a resistance consisting of eight 50 c. p. lamps in parallel, from a 105 volt continuous current supply. To the positive and negative terminals of the secondary of the induction coil were connected respectively the inside and outside coatings of three half-gallon Leyden jars, connected in parallel. The disruptive discharge of these jars across an air gap of about a quarter of an inch excited the primary of a simple form of high frequency coil, similar to those employed by Mr. Tesla and Prof. Elihu Thomson. The secondary of this coil consisted of 500 turns of No. 26 S. W. G. cotton covered wire wound on a paper tube. [illegible] the paper tube was a glass tube, upon which the primary, consisting of 10 turns of three No. 16 gutta percha covered wires, in parallel, were wound. The whole coil was immersed in resin oil contained in a wooden trough. The ends of the secondary were connected through small glass tubes, also filled with oil, to brass balls.

On approaching the hand to one of the balls forming the terminals of the oil coil, sparks shoot out from the brush discharge [illegible]. If the sparks [illegible] the skin a sharp prick is felt, but on approaching the terminal or touching it with a piece of metal grasped in the hand, or after grasping the terminal itself, practically no appreciable sensation is felt. If the terminal is grasped in this manner with the right hand, sparks will shoot out from the left hand or indeed from any portion of the body, if brought into proximity with another person, a piece of metal, the gas or water pipes or any conducting body. In the experiment referred to, the incandescent lamp was hung by one terminal on a wire connected to earth and connection was made between the other lamp terminal and the coil through the two arms and body by the right hand being brought into contact with one terminal of the oil coil, and a piece of metal grasped in the left hand being approached to the free terminal of the lamp. At the first approach the bulb of the lamp became filled with phosphorescent light, but on reducing the distance between the metal in the left hand and the free lamp terminal, sparks shot out between them and the filament at once became incandescent, the incandescence increasing very nearly to the full normal amount when the piece of metal and the lamp terminal were finally brought into contact.

To produce a similar incandescence of the filament with continuous or alternating currents of ordinary frequency would require about one-fifth of an ampere, and at first sight it would seem that this quantity of current might pass through the arms and body of the operator.

It has been generally assumed that with high frequency currents the current is rendered harmless by reason of the high frequency, in fact, that high frequency renders harmless to the body currents of a strength that would be dangerous and, if not fatal, were the frequency lower. The author is inclined to think that another explanation is possible and that the fact is not that high frequency renders harmless a given strength of current that with ordinary frequency would be harmful, but that with high frequency it is possible to obtain effects with exceedingly small currents, that with continuous and ordinary alternating currents can only be obtained by the use of much larger currents.

This hypothesis [illegible] many other high frequency effects, but as applied to the above mentioned experiment is simply this. The lamp filament having a certain definite resistance with continuous or ordinary alternating currents which pass uniformly or nearly so through the section of the filament, a certain amperage of current is necessary to produce the number of watts required to raise the filament to incandescence. With the high frequency currents on the other hand, as is well understood, the current travels chiefly on the outer surface of the filament, little or none passing through the central portion. The current is in fact merely skin deep. The virtual resistance is therefore very high, as only an extremely small portion of the sectional area of the filament acts as a conductor. There is an ample [illegible] though the current is very minute there is a sufficient expenditure of watts to raise the filament to incandescence. The [illegible] in fact, ceases to be a 100-volt lamp and becomes, it may well be, a 100,000-volt lamp. As [illegible] this hypothesis it should be mentioned that while the [illegible] was incandescent, sparks passed between the lamp terminals which were at some distance apart, this being evidence that there was a difference of potential amounting at least to thousands of volts between the two ends of the filament.

Returning to the experiments, several other curious results were obtained. If instead of connecting the lamp to the coil through the human frame a wire was used, the filament became much brighter than in the previous experiment. In fact, it gave considerably above its normal candle power. From this it was evident that the human body offered considerable opposition of some description to the passage of the electricity. In order to form some idea of the amount of this opposition the body was again inserted in the circuit between the coil and the lamp as previously, and the thumbs of the two hands brought near together. Sparks about one-quarter of an inch in length were found to pass between them, evidencing that the two [illegible] of the operator had a difference of potential between them [illegible] equal to some thousands of volts. When the sparks [illegible] between the hands, or when the wrists were brought into [illegible] so, as it were, to short circuit to some extent the resistance of the arms and body, the filament became very appreciably brighter. It should be mentioned that when the sparks were allowed to pass between the hands very perceptible shocks were felt in the wrists.

Another experiment was to connect one lamp terminal by a wire to the coil, connect the other lamp terminal to earth, and short circuit the lamp through the body by grasping the coil terminal with one hand and a piece of metal connected to earth with the other. The effect of so doing was to reduce the incandescence of the filament to rather less than one-half its normal amount, half of the available current going apparently through the lamp, the other half through the body.

With the lamp terminal connected to the coil, it was found unnecessary to connect the other lamp terminal to earth to produce incandescence, all that was necessary being to touch this lamp terminal with a piece of metal held in the hand. That the incandescence of the filament produced under these conditions was due to the electrostatic capacity of the operator and not to his forming a connection to earth, was evidenced by the fact that it made no perceptible difference whether he stood on the floor or on an insulated stool.

In all the above experiments the second terminal of the oil coil was free and not connected to anything. It was however found that the effect of a second operator touching this terminal, or of connecting it by wire to earth, was to diminish the incandescence of the lamp filament. It was also found that the filament incandesced to a greater degree of brightness when connected as above between one terminal of the coil and earth, than when it was directly connected between the two terminals of the coil. This seems to show that capacity has much to do with the results obtained.

It should also be mentioned that in some of the experiments there was a decided tendency for the filament to vibrate in unison with the contact breaker of the induction coil. In fact in some cases the amplitude of vibration was sufficient to cause the end of the filament to beat against the glass of the lamp bulb.

ALTERNATE CURRENTS OF HIGH POTENTIAL AND HIGH FREQUENCY.—III.

(Concluded.)

BY NIKOLA TESLA.

One of the most interesting results arrived at in pursuing these experiments, is the demonstration of the fact that a gaseous medium upon which vibration is impressed by rapid changes of electrostatic potential, is rigid. In illustration of this result an experiment may be cited: A glass tube about 1 inch in diameter and 3 feet long, with outside condenser coatings on the ends, was exhausted to a certain point, when, the tube being suspended freely from a wire connecting the upper coating to one of the terminals of the coil, the discharge appeared in the form of a luminous thread, passing through the axis of the tube. Usually the thread was sharply defined in the upper part of the tube and lost itself in the lower part. When a magnet or the finger was quickly passed near the upper part of the luminous thread, it was brought out of position by magnetic or electrostatic influence, and a transversal vibration like that of a suspended cord, with one or more distinct nodes, was set up, which lasted for a few minutes and gradually died out. By suspending to the lower condenser coating metal plates of different sizes, the speed of the vibration was varied. This vibration would seem to show beyond doubt that the thread possessed rigidity, at least to transversal displacements.

Many experiments were tried to demonstrate this property in [illegible]

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One of the most interesting results arrived at in pursuing these experiments, is the demonstration of the fact that a gaseous medium upon which vibration is impressed by rapid changes of electrostatic potential, is rigid. In illustration of this result an experiment may be cited: A glass tube about 1 inch in diameter and 8 feet long, with outside condenser coatings on the ends, was exhausted to a certain point, when, the tube being suspended freely from a wire connecting the upper coating to one of the terminals of the coil, the discharge appeared in the form of a luminous thread, passing through the axis of the tube. Usually the thread was sharply defined in the upper part of the tube and lost itself in the lower part. When a magnet or the finger was quickly passed near the upper part of the luminous thread, it was brought out of position by magnetic or electrostatic influence, and a transversal vibration like that of a suspended cord, with one or more distinct nodes, was set up, which lasted for a few minutes and gradually died out. By suspending from the lower condenser coating metal plates of different sizes, the speed of the vibration was varied. This vibration would seem to show beyond doubt that the thread possessed rigidity, at least to transversal displacements.

Many experiments were tried to demonstrate this property

In observing the behavior of gases, and the luminous [illegible] obtained, the importance of the electrostatic effects was [illegible] it appeared desirable to produce enormous potential diff[illegible] alternating with extreme rapidity. Experiments in this directio[n] led to some of the most interesting results arrived at in the cours[e] of these investigations. It was found that by rapid alternation[s] of a high electrostatic potential, exhausted tubes could be l[illegible] at considerable distance from a conductor connected to a [illegible] constructed coil, and that it was practicable to establish [illegible] coil an alternating electrostatic field, acting through the [illegible] extent of a room and lighting a tube, wherever it was placed [illegible] the same. Phosphorescent bulbs may be excited in such a field, and it is easy to regulate the effect by connecting to the bulb [a] small insulated metal plate. It was likewise possible to maintain a filament or button mounted in a tube at bright incandescence, and in one experiment, a mica vane was spun by the [illegible]cence of a platinum wire.

It is hoped that the study of these phenomena, [illegible] tion of the means for obtaining rapidly alternating high po[ten]tials, will lead to the production of an efficient illuminant.

[TH]E UTILIZATION OF NIAGA[RA] [illegible]

(Concluded.)

BY PROF. GEORGE FORBES, [illegible]

Having now given some [illegible] work, and of the engineering construction, it will be well to [say] something about the manner in which this power is to be distrib-

[illegible] of ordinary pressure. Though no [illegible] obtained, it is thought nevertheless, that a high frequency brush or streamer, if the frequency could be pushed far enough, would be decidedly rigid. A small sphere might then be moved within it quite freely, but if thrown against it the sphere would rebound. An ordinary flame cannot possess rigidity to a marked degree because the vibration is directionless; but an electric arc, it is believed, must possess that property more or less. A luminous band excited in a bulb by repeated discharges of a Leyden jar must also possess rigidity, and if deformed and suddenly released should vibrate.

From like considerations other conclusions of interest may be made. The most probable medium filling the space is one consisting of independent carriers immersed in an insulating fluid. If through the medium enormous electrostatic stresses are assumed to act, which vary rapidly in intensity, it would allow the motion of a body through it, yet it would be rigid and elastic, although the fluid itself might be devoid of these properties. Furthermore, on the assumption that the independent carriers are of any configuration such that the fluid resistance to motion in one direction is greater than in another, a stress of that nature would cause the carriers to arrange themselves in groups, since they would turn to each other their sides of the greatest electric density, in which position the fluid resistance to approach would be smaller than to receding. If in a medium of the above characteristics a brush would be formed by a steady potential, an exchange of the carriers would go on continually, and there would be less carriers per unit of volume in the brush than in the space at some distance from the electrode, this corresponding to rarefaction. If the potential were rapidly changing, the result would be very different; the higher the frequency of the pulses, the slower would be the exchange of the carriers; finally, the motion of translation through measurable space would cease, and, with a sufficiently high frequency and intensity of the stress, the carriers would be drawn towards the electrode, and compression would result.

An interesting feature of these high frequency currents is that they allow to operate all kinds of devices by connecting the device with only one leading wire to the source. In fact, under certain conditions it may be more economical to supply the electrical energy with one lead than with two.

An experiment of special interest is the running, by the use of only one insulated line, of a motor operating on the principle of the rotating magnetic field enunciated by the author a few years ago. A simple form of such a motor is obtained by winding upon a laminated iron core a primary and close to it a secondary coil, closing the ends of the latter and placing a freely movable metal disc within the influence of the moving field. The secondary coil may, however, be omitted. When one of the ends of the primary coil of the motor is connected to one of the terminals of the high-frequency coil and the other end to an insulated metal plate, which, it should be stated, is not absolutely necessary for the success of the experiment, the disc is set in rotation.

Experiments of this kind seem to bring it within the reach of possibility to operate a motor at any point of the earth's surface from a central source, without any connection to the same except through the earth. If, by means of powerful machinery, rapid variations of the earth's potential were produced, a grounded wire reaching up to some height would be traversed by a current which could be increased by connecting the free end of the wire to a body of some size. The current might be converted to low tension and used to operate a motor or other device. The experiment, which would be one of great scientific interest, would probably best succeed on a ship at sea. In this manner, even if it were not possible to operate machinery, intelligence might be transmitted quite certainly.

In the course of this experimental study special attention was devoted to the heating effects produced by these currents, which are not only striking, but open up the possibility of producing a more efficient illuminant. It is sufficient to attach to the coil terminal a thin wire or filament, to have the temperature of the latter perceptibly raised. If the wire or filament be inclosed in a bulb, the heating effect is increased by preventing the circulation of the air. If the air in the bulb be strongly compressed, the displacements are smaller, the impacts less violent, and the heating effect is diminished. On the contrary, if the air in the bulb be exhausted, an inclosed lamp filament is brought to incandescence, and any amount of light may thus be produced.

The heating of the inclosed lamp filament depends on so many things of a different nature, that it is difficult to give a generally applicable rule under which the maximum heating occurs. As regards the size of the bulb, it is ascertained that at ordinary or only slightly differing atmospheric pressures, when air is a good insulator, the filament is heated more in a small bulb, because of the better confinement of heat in this case. At lower pressures, when air becomes conducting, the heating effect is greater in a large bulb, but at excessively high degrees of exhaustion there [illegible] a certain and rather small size of the [illegible] difference in the heating.

[illegible] and it has [illegible] bounding molecules collide. It is desirable on account of economy that all the energy supplied to the bulb from the source should reach without loss the body to be heated. The loss in conveying the energy from the source to the body may be reduced by employing thin wires heavily coated with insulation, and by the use of electrostatic screens. It is to be remarked, that the screen cannot be connected to the ground as under ordinary conditions.

In the bulb itself a large portion of the energy supplied may be lost by molecular bombardment against the wire connecting the body to be heated with the source. Considerable improvement was effected by covering the glass stem containing the wire with a closely fitting conducting tube. This tube is made to project a little above the glass, and prevents the cracking of the latter near the heated body. The effectiveness of the conducting tube is limited to very high degrees of exhaustion. [illegible] energy lost in bombardment for two [illegible] given up by the atoms spreads over [illegible] electric density at any point is small, and the atoms [illegible] with less energy than if they would strike against [illegible] tor; secondly, as the tube is electrified by the [illegible] come in contact with it, the progress of the [illegible] against the tube is more or less checked by the repulsion [illegible] electrified tube must exert upon the similarly electrified [illegible] This, it is thought, explains why the discharge through a [illegible] established with much greater facility when an [illegible] when a conductor is present.

During the investigations great many bulbs of differ[illegible]struction, with the electrodes of different material, [illegible] mented upon, and a number of observations of inte[illegible] It was found that the deterioration of the electrode [illegible] the higher the frequency. This was to be expected [illegible] heating is effected by many small impacts, instead of [illegible] more violent ones, which quickly shatter the [illegible] terioration is also smaller when the vibration is [illegible] an electrode, maintained at a certain degree of heat, [illegible] longer with currents obtained from an alternator, than [illegible] obtained by means of a disruptive discharge. One of [illegible] durable electrodes was obtained from strongly compressed [illegible]rundum, which is a kind of carbon recently produced by [illegible] G. Acheson. From experience, it is inferred, that to be most [illegible]able, the electrode should be in the form of a sphere with a [illegible] polished surface.

In some bulbs refractory bodies were mounted in a car[illegible] and pushed under the molecular impact. It was [illegible] experiments that the carbon cup was heated at first, [illegible] temperature was reached; then most of the bombardment [illegible] directed against the refractory body, and the carbon was [illegible] In general, when different bodies were mounted in the bulb, [illegible] would be relieved, and would remain at a con[illegible]erably lower temperature. This was necessitated by the fact that most of the energy supplied would find its way through [illegible] which was easier fused or "evaporated." Curiously [illegible] appeared in some of the experiments made, that a body [illegible] in a bulb under the molecular impact by evolution of [illegible] than when fused by the application of heat in ordinary [illegible] This may be ascribed to a loosening of the structure of the [illegible] under the violent impacts and changing stresses.

Some experiments seem to indicate that under certain conditions a body, conducting, or non-conducting, may, when [illegible]barded, emit light, which to all appearance is due to phos[illegible]cence, but may in reality be caused by the incandescence of [illegible] infinitesimal layer, the mean temperature of the body being com[illegible]paratively small. Such might be the case if each single rythm[illegible] impact were capable of instantaneously exciting the retina [illegible] the rythm just high enough to cause a continuous impression [illegible] the eye. According to this view, a coil operated by disruptive discharge would be eminently adapted to produce such a result, and it is found by experiment that its power [illegible] escence is extraordinarily great. It is capable of exciting [illegible]phorescence at comparatively low degrees of exhaustion, and also projects shadows at pressures far greater than those at which the mean free path is comparable to the dimensions of the vessel. The latter observation is of some importance, inasmuch [illegible] modify the generally accepted views [illegible] state" phenomena.

A thought, which early [illegible] utilize the great inductive [illegible] of high frequency currents [illegible] produce light in a sealed glass vessel without [illegible] wires. Accordingly, many bulbs were constructed [illegible] energy necessary to maintain a button or filament [illegible] descence, was supplied through the glass either [illegible] electrodynamic induction. It was likewise easy to regulate [illegible] intensity of the light emitted by means of an externally ap[illegible] condenser coating connected to an insulated plate, or simply [illegible] means of a plate attached to the bulb which at the same time [illegible]formed the function of a shade.

A subject of experiment, which has been exhaustively trea[illegible] by Prof. J. J. Thomson, has been followed up independently by [illegible] author from the beginning of this study, namely, to excite by [illegible] [illegible] induction a luminous band in a closed [illegible]

period, especially if the condenser [illegible] charged to a very high potenti[illegible] are dependent upon the corre[illegible] vibration period, this subject demand[illegible] of other investigators.

In Leyden jars the loss due to the presence of air [illegible] tively small, principally on account of the great surfa[illegible] coatings and the small external action, but if there are [illegible] [illegible]op, [illegible] considerable, and the period of vibra[illegible] tion is affected. In a resonator, the density is [illegible] [illegible] is extreme, and may introduce a considerable erro[illegible] [illegible] certain, at any rate, that the periods of vibration of a [illegible]ged body in a gaseous and in a continuous medium, such as [illegible] [illegible] explained.

An[illegible] [illegible] in [illegible] [illegible]gations the general [illegible]tions of [illegible] screening [illegible] applicable when a gaseous medium is present. This is evident from the following experiment: A short and wide glass tube is taken and covered with a [illegible] bronze, barely allowing the light to shine a little through. The tube is highly [illegible] and suspended on a metal[illegible] from the end of a wire. When the wire is connected with one of the terminals of the [illegible] the [illegible] of the tube is [illegible] [illegible] of the metal coating. Here the metal evidently does not [illegible] the gas inside [illegible] ought to, even if it be very [illegible] [illegible] conducting. [illegible] condition of [illegible] however thin, screens the inside perfectly.

PROVISIONAL PROGRAMME FOR THE INTERNATIONAL ELECTRICAL CONGRESS OF 1893.

[illegible] Committee of the American Institute of Electrical Engineers [illegible] just received the report of [illegible] sub-committee, embodying a provisional programme for the conduct and [illegible] of the Congress to be held in Chicago during this year.

The sub-committee consisting of Mr. Carl Hering, chairman; Prof. Wm. A. Anthony and Mr. A. E. Kennelly made the following [illegible] of [illegible] report.

RECOMMENDATIONS.

(1.) *Ratification of the adoption of units, terms [illegible] made by previous International Electrical Congresses.*

Defining and adopting practical units [illegible] the measurements of the following quantities: magneto-motive force; magnetic flux; magnetic [illegible]; magnetic reluctance; electric conductivity; illumination.

[illegible] Committee recommends the following [illegible]

[illegible] be very small, the loss caused by the impacts and collisions [illegible] unless the potential were excessive; but when [illegible] high frequencies and more or less high potentials are used, the loss may be very great. The total energy lost per unit of time is proportionate to the product of the number of impacts per second, or the frequency and the energy lost in each impact. But the energy of an impact must be proportionate to the square of the electric density of the body, on the assumption that the charge imparted to the molecule is proportionate to that density. It is concluded from this that the total energy lost must be proportionate to the product of the frequency and the square of the electric density; but this law needs experimental confirmation. Assuming the preceding considerations to be true, then, by rapidly alternating the potential of a body immersed in an insulating gaseous medium, any amount of energy may be dissipated into space. Most of that energy, then, is not dissipated in the form of long ether waves, propagated to considerable distance, as is thought most generally, but is consumed in impact and collisional losses—that is, heat vibrations—on the surface and in the vicinity of the body. To reduce the dissipation it is necessary to work with a small electric density—the smaller the higher the frequency.

The behavior of a gaseous medium under such rapid alternations of potential makes it appear plausible that electrostatic disturbances of the earth, produced by cosmic events, may have great influence upon the meteorological conditions. When such disturbances occur, both the frequency of the vibrations of the charge and the potential are in all probability excessive, and the energy converted into heat may be considerable. Since the density [illegible] in consequence of the [illegible] of the earth's surface, or on account of the condition of the atmosphere in various places, the effect produced would accordingly vary from place to place. Considerable variations in the temperature and pressure of the atmosphere may in this [illegible] caused at any point of the surface of the earth. The [illegible] may be gradual or very sudden, according to the nature of the original disturbance, and may produce rain and [illegible] modify the weather in any way.

From many experiences [illegible] it appears certain that in lightning discharges the [illegible] element of importance. For instance, during a storm a [illegible] may form on a nail or pointed projection of a building. If lightning strikes somewhere in the neighborhood, the [illegible] discharge may, in consequence of the oscillations set up, [illegible] the character of a high frequency streamer, and the nail or projection may be brought to a high temperature by the violent impact of the air molecules. Thus, it is thought, a [illegible] set on fire without the lightning striking it. In like [illegible] metallic objects may be fused and volatilized—as frequently occurs in lightning discharges—merely because they are [illegible] air. Were they immersed in a practically continuous [illegible] such as oil, they would probably [illegible] as the energy [illegible] to spend itself elsewhere.

An instructive experiment [illegible] the following:—A glass tube of an inch or so in diameter and several inches long is taken, and a platinum wire sealed into it, the wire running through the centre of the tube from end to end. The tube is exhausted to a moderate degree. If a steady current is passed through the wire it is heated uniformly in all parts and the gas in the tube is of no consequence. But if high frequency discharges are directed through the wire, it is heated more on the ends than in the middle portion, and if the frequency, or rate of charge, is high enough, the wire might as well be cut in [illegible] as not, for most of the heating on the ends is due to the rarefied gas. [illegible] might [illegible] act as a conductor of no impedance, diverting the current from the wire as the impedance of the latter is enormously increased, and merely heating the ends of the wire by reason of their resistance to the passage of the discharge. But it is not at all necessary that the gas in the tube should be conducting; it might be at an extremely low pressure, still the ends of the wire would be heated; as, however, is ascertained by experience, only the two ends would in such case not be electrically connected through the gaseous medium. Now what [illegible] frequencies and potentials occur in an [illegible] the lightning discharge at ordinary pressure.

[illegible] the facility with which any amount of energy [illegible] off through a gas [illegible] lightning discharge [illegible] passage through a volume of gas.

The recognition of some [illegible] scientific inv[illegible] potentials a[illegible] such [illegible] to be consid[illegible] instance [illegible] the terminal [illegible] and [illegible] dissipation of energy in the form of heat and light, and the wires behave like a condenser of large capacity. If the wires be immersed in oil, the dissipation of energy is prevented, or at least reduced, and the apparent capacity is diminished. The action of the air would seem to make it very difficult to tell, from the measured or computed capacity of a condenser in which the air [illegible]

when it is at right angles to the lines of force of the earth, very likely rotates, when at its maximum speed, in synchronism with the alternations, say 10,000 times a second. The rotation can be slowed down or accelerated by the approach or receding of the observer or any conducting body, but it cannot be reversed by putting the bulb in any position. Very curious experiments may be performed with the brush when in its most sensitive state. For instance, the brush resting in one position, the experimenter may, by selecting a proper position, approach the hand at a certain considerable distance to the bulb, and he may cause the brush to pass off by merely stiffening the muscles of the arm, the mere change of configuration of the arm and the imperceptible displacement being sufficient to disturb the delicate balance. When it begins to rotate slowly, and the hands are held at a proper distance, it is impossible to make the slightest motion without producing a visible effect upon the brush. A metal plate connected to the other terminal of the coil affects it at a great distance, slowing down the rotation often to one turn a second.

It is hoped that this phenomenon will prove a valuable aid in the investigation of the nature of the forces acting in an electrostatic or magnetic field. If there is any motion which is measurable going on in the space, such a brush would be apt to reveal it. It is, so to speak, a beam of light, frictionless, devoid of inertia. On account of its marvellous sensitiveness to electrostatic or magnetic disturbances it may be the means of sending signals through submarine cables with any speed, and even of transmitting intelligence at a distance without wires.

LETTERS TO THE EDITOR.

THE DRIFTLESS BALLISTIC GALVANOMETER.

amperes passing through the coil, becomes within two sec- [illegible] wood. Beyond a certain frequency [illegible] point at which the magne- [illegible] by the presence of a core consist- ing of a bundle of very thin well annealed and varnished iron wire.

[illegible]ents with a telephone, a conductor in a strong mag- netic field, or with a condenser or arc, seem to afford certain proof that sounds far above the usually accepted limit of hearing would be perceived if produced with sufficient power.

The arc produced by these currents possesses several interest- ing features. Usually it emits a note the pitch of which corre- [illegible] to the frequency of the currents, but if the frequency is sufficiently high it becomes noiseless, the limit of audition be- ing determined principally by the linear dimensions of the arc. A curious feature of the arc is its persistency, which is due partly to the inability of the gaseous column to cool and increase con- siderably in resistance, as in the case with low frequencies, and partly to the tendency of such a high frequency machine to main- tain a constant current.

In connection with these machines the condenser affords a particularly interesting study. Striking effects are produced by proper adjustments of capacity and self-induction. It is easy to raise the E. M. F. of the machine to many times the original value by simply adjusting the capacity of a condenser [illegible] in the induced circuit. If the condenser be at some distance from the machine, the difference of potential on the terminals of the latter may be only a small fraction of that [illegible]

[illegible] generally alike, though [illegible] one current impulse [illegible]

The physiological effects of the high tension discharge are found to be so small that the shock of the coil can be supported without any inconvenience, except perhaps a small burn produced by the discharge upon approaching the hand to one of the termi- nals. The decidedly smaller physiological effects of these cur- rents are thought to be due either to a different distribution through the body or to the tissues acting as condensers. But in the case of an induction coil with great many turns the harmless- ness is principally due to the fact that but little energy is available in the external circuit when the same is closed through the ex- perimenter's body, on account of the great impedance of the coil.

In varying the frequency and strength of the currents through the primary of the coil, the character of the secondary discharge is greatly varied, and no less than five distinct forms are observed: a weak, sensitive thread discharge, a powerful flaming discharge, and three forms of brush or streaming discharge. Each of these possesses certain noteworthy features, but the most interesting to study are the latter. Under certain conditions the streams, which are presumably due to the violent agitation of the air molecules, issue freely from all points of the coil, even through a thick insulation. If there is the smallest air space between the primary and secondary, they will form there and surely injure the coil by slowly warming the insulation. As they form even with ordinary frequencies when the potential is excessive, the air-space must be most carefully avoided.

These high frequency streamers differ in aspect and properties from those produced by a static machine. The wind produced by them is small and should altogether cease if still considerably higher frequencies could be obtained. A peculiarity is that they issue as freely from surfaces as from points. Owing to this, a metallic vane, mounted in one of the terminals of the coil so as to rotate freely, and having one of its sides covered with insulation, is spun rapidly around. Such a vane would not rotate with a steady potential, but with a high-frequency coil it will spin, even if it be entirely covered with insulation, provided the insulation on one side be either thicker or of a higher specific inductive capacity. A Crookes electric radiometer is also spun around when connected to one of the terminals of the coil, but only at very high exhaustion or at ordinary pressures.

There is still another and more striking peculiarity of such a high frequency streamer, namely, it is hot. The heat is easily perceptible with frequencies of about 10,000, even if the potential is not excessively high. The heating effect is, of course, due to the molecular impacts and collisions. Could the frequency and potential be pushed far enough, then a brush could be produced resembling in every particular a flame and giving light and heat, yet without a chemical process taking place. The hot brush, when properly produced, resembles a jet of burning gas escaping under great pressure, and it emits an extraordinary strong smell of ozone. The great ozonizing action is ascribed to the fact that the agitation of the molecules of the air is more violent in such a brush than in [illegible] static machine.

But the most powerful brush discharges are produced by employing currents of much higher frequencies than it was possible to obtain by means of the alternators. These are obtained by disruptively discharging a condenser and [illegible] oscillations. In this manner currents of a frequency of [illegible] hundred thousand were obtained. Currents of this kind [illegible] striking effects. At these frequencies, the impedance of a [illegible] bar is so great that a potential difference of several hundred volts can be maintained between two points of a short and thick bar, and it is possible to keep an ordinary incandescent lamp burning at full candle power by attaching the terminals of the lamp to two points of the bar, no more than a few inches apart. When the frequency is extremely high, nodes are found to exist on such a bar, and it is easy to locate them by [illegible].

By converting the high-tension discharges of a low-frequency coil in this manner, it was found practicable to keep a few lamps burning on the ordinary circuit in the laboratory, and by bring- ing the undulation to a low pitch, it was possible to operate [illegible] motors. This plan likewise allows of converting [illegible] charges of one direction into low tension [illegible] by adjusting the circuit so that there are [illegible] passing the oscillating discharges through the [illegible] specially-constructed coil, it is easy to obtain [illegible] differences with only few turns of the secondary.

Great difficulties were at the beginning experienced in [illegible] a successful coil on this plan. It was found necessary [illegible] all air, or gaseous matter in general, away from the charged [illegible], and oil immersion was resorted to. The wires used were heavily covered with gutta-percha and wound in oil, or air was pumped out by means of a Sprengel pump.

The general arrangement was the following: An ordinary in- duction coil, operated from a low-frequency [illegible] to charge Leyden jars. The jars were made to discharge over a single or multiple gap through the primary of the second coil. To insure the action of the gap, the arc was blown out by a magnet or air-blast. To adjust the potential in the secondary a small oil condenser was used, or polished brass spheres of different sizes were screwed on the terminals and their distance [illegible]

When the conditions were carefully determined to suit each experiment, magnificent effects were obtained.

Two wires, stretched through the room, each being connected to one of the terminals of the coil, emit streams so powerful that the light from them allows distinguishing the objects in the room; the wires become luminous even if covered with thick and most excellent insulation. When two straight wires, or two concentric circles of wire, are connected to the terminals, and set at the proper distance, a uniform luminous sheet is produced between them. It was possible in this way to cover an area of more than one meter square completely with the streams. By attaching to one terminal a large circle of wire and to the other terminal a small sphere, the streams are focused upon the sphere, produce a strongly lighted spot upon the same, and present the appearance of a luminous cone. A very thin wire glued upon a plate of hard rubber of great thickness, on the opposite side of which is fast- ened a tinfoil coating, is rendered intensely luminous when the coating is connected to the other terminal of the coil. Such an experiment can be performed also with low frequency currents, but much less satisfactorily.

When the terminals of such a coil, even of a very small size, are separated by a rubber or glass plate, the discharge spreads over the plate in the form of streams, threads, or brilliant sparks, and affords a magnificent display, which cannot be equalled by the largest coil operated in the usual ways. By a simple adjust- ment it is possible to produce with the coil a succession of brush sparks, exactly like with a Holtz machine.

Under certain conditions, when the frequency of the oscilla- tion is very great, white phantom-like streams are seen to break forth from the terminals of the coil. The chief interesting feat- ure about them is, that they stream freely against the outstretched hand or other conducting object without producing any sensa- tion, and the hand may be approached very near to the terminal without a spark being induced to jump. This is due [illegible] to the fact that a considerable portion of the energy is carried away or dissipated in the streamers, and the difference of poten- tial between the terminal and the hand is diminished.

It is found in such experiments that the frequency of the vi- bration and the quickness of succession of the sparks between the knobs affect to a marked degree the appearance of the streams. When the frequency is very low, the air gives way in more or less the same manner as by a steady difference of potential, and the streams consist of distinct threads, generally mingled with thin sparks, which probably correspond to the successive discharges occurring between the knobs. But when the frequency is very high, and the arc of the discharge produces a sound which is loud and smooth (which indicates both that oscillation takes place and that the sparks succeed each other with great rapidity), then the luminous streams formed are perfectly uniform. [illegible] of a purplish hue, but when the [illegible] by [illegible] the potential they [illegible]

The luminous intensity of the streams increases rapidly when

the potential is increased; and with frequencies of only a few hundred thousand, could the coil be made to withstand a sufficiently high potential difference, there is no doubt that the space around a wire could be made to emit a strong light, merely by the agitation of the molecules of the air at ordinary pressure.

Such discharges of very high frequency which render luminous the air at ordinary pressure we have very likely occasion to witness in the aurora borealis. From many of these experiments it seems reasonable to infer that sudden cosmic disturbances, such as eruptions on the sun, set the electrostatic charge of the earth in an extremely rapid vibration, and produce the glow by the violent agitation of the air in the upper and even in the lower strata. It is thought that if the frequency were low, or even more so if the charge were not at all vibrating, the lower, dense strata would break down as in a lightning discharge. Indications of such breaking down have been repeatedly observed, but they can be attributed to the fundamental disturbances, which are few in number, for the superimposed vibration would be so rapid as to not allow a disruptive break.

The study of these discharge phenomena has led to the recognition of some important facts. It was found that gaseous matter must be most carefully excluded from any dielectric which is subjected to great, rapidly-changing electrostatic stresses. Since it is difficult to exclude the gas perfectly when solid insulators are used, it is necessary to resort to liquid dielectrics. When a solid dielectric is used, it matters little how thick and how good it is; if air be present streamers form, which gradually heat the dielectric and impair its insulating power, and the discharge finally breaks through. Under ordinary conditions the best insulators are those which possess the highest specific inductive capacity, but such insulators are not the best to employ when working with these high frequency currents, for in most cases the higher specific inductive capacity is rather a disadvantage. The prime quality of the insulating medium for these currents is continuity. For this reason principally it is necessary to employ liquid insulators, such as oils. If two metal plates, connected to the terminals of the coil, are immersed in oil and set a distance apart, the coil may be kept working for any length of time without a break occurring, or without the oil being warmed, but if air bubbles are introduced, they become luminous; the air molecules, by their impact against the oil, heat it and after some time cause the insulation to give way. If, instead of the oil, a solid plate of the best dielectric, even several times thicker than the oil intervening between the metal plates, is inserted between the latter, the air having free access to the charged surfaces, the dielectric invariably is warmed and breaks down. The employment of the oil is advisable or necessary even with low frequencies, if the potentials are such that streamers form, but only in such cases, as is evident from the theory of the action. If the potentials are so low that streamers do not form, then it is even disadvantageous to employ oil, for it may, principally by confining the heat, be the cause of the breaking down of the insulation. The exclusion of gaseous matter is not only desirable on account of the safety of the apparatus, but also on account of economy, especially in a condenser, in which considerable waste of power may occur merely owing to the presence of air, if the electric density on the charged surfaces is great.

In the course of these investigations a phenomenon of special scientific interest has been observed. It may be ranked among the brush phenomena, in fact it is a kind of brush which forms at, or near, a single terminal in high vacuum. In a bulb with a conducting electrode, even if the latter be of aluminum, the brush has only a very short existence, but it can be preserved for a considerable length of time in a bulb devoid of any conducting electrode. To observe the phenomenon it is found best to employ a large spherical bulb having in its centre a small bulb supported on a tube sealed to the neck of the former. The large bulb being exhausted to a high degree, and the inside of the small bulb being connected to one of the terminals of the coil, under certain conditions there appears a misty haze around the small bulb, which, after passing through some stages, assumes the form of a brush, generally at right angles to the tube supporting the small bulb. When the brush assumes this form it may be brought to a state of extreme sensitiveness to electrostatic and magnetic influence. The bulb hanging straight down, and all objects being remote from it, the approach of the observer within a few paces will cause the brush to fly to the opposite side, and if he walks around the bulb it will always keep on the opposite side. It may begin to spin around the terminal long before it reaches that sensitive stage. When it begins to turn around, principally, but also before, it is affected by a magnet, and at a certain stage it is susceptible to magnetic influence to an astonishing degree. A small permanent magnet, with its poles at a distance of no more than two centimetres, will affect it visibly at a distance of two metres, slowing down or accelerating [illegible] held relatively to the brush.

When the bulb hangs with [illegible] always clockwise. In the southern hemisphere it would occur in

[illegible] lamps. His ability to produce such effects, either with a [illegible] wire and no return, or without any wires at all, aroused [illegible] result.

[illegible] were specially referred to, one of [illegible] eye [illegible] ed by the eye in furnishing the race with its ideas and knowl[illegible] [illegible] that were impossible without images—and images [illegible]

[illegible] of these phenomena, and of their relations. It was stated [illegible] physiological effects produced [illegible] the high tension, high frequency currents employed, that a great amount of energy may be sent into the body of a person [illegible] their means, merely because the energy was dissipated laterally from the body and was not passed through the body in the direct manner involved in the use of a low frequency current. It was [illegible] the lecturer was able [illegible] 000 and 500,000 [illegible] would kill [illegible] apparatus that [illegible] case of any failure of any part of it, the current would kindly [illegible] tain from killing him, and would only knock him down. [illegible]

Many of the experiments shown have already been [illegible] in this country or in Europe, yet there were several novel [illegible]

[illegible] experiments were performed with apparatus different from [illegible] of the experiment [illegible] from the other [illegible] the lecture [illegible] through the dielectric. This experiment was performed by grasping one terminal [illegible] erable energy and developed abundantly ozone and nitrous acid, and it followed [illegible] tension apparatus.

The action of the air was shown in another very striking experiment. Two incandescent lamps exactly alike, one exhausted [illegible]

[illegible] the stage, one o[illegible] from [illegible] from the regular direct [illegible] discharger was used [illegible] The spark-gap was [illegible] by a [illegible] purpose of making the [illegible] [illegible] work with a [illegible] comparatively small [illegible] whatever in obtaining [illegible] the method of conversion [illegible] two-volt lamp were brought up to full candle-power with equal facility. Then a little [illegible] it being a [illegible] with a closed [illegible] to rotate above the [illegible] that if the demonstration were not quite equal to the [illegible] the long continued and weary work on the development of the invention, besides the inability of the experimenter, might be the cause. He went on in connection with this to [illegible]

[illegible] more spectacular nature with reluctance [illegible] forced thereto [illegible] the desire [illegible] and formed [illegible] were performed [illegible] had been shown in England [illegible]

The Tesla lecture was a notable feature of the [illegible]vention. At first it had [illegible] proposed to deliver the le[illegible]ture in a small hall, but the demand for tickets was so enormous that it was decided, as a matter of sheer necessity, to secure a larger auditorium, and this was found in the Exhibition Theatre, which seats about 4,000 people. It was, of course, practically impossible that all could hear and see, but those who were there could at least say they had seen Mr. Tesla afar off and witnessed s[illegible] most striking experim[illegible]. The hall was crowded to suf[illegible]focation, and the demand for tickets was so great that they were selling briskly for three and five [illegible] the steps of the hall. Under such circumstances Mr. Tesla contented himself wisely with showing some of the more "spectacular" [illegible] his experiments, and even these were followed at a disadvantage [illegible] of the immense distance from which most of the specta[illegible] studied them. After his introduction by Mr. Ayer, the lecturer [illegible] a few minutes to a statement of the conditions involved in [illegible] work, and then by means of his high frequency and high vol[illegible]tage currents, aided by disruptive discharge from a condenser [illegible]rough an induction coil—as well as by direct dynamic pheno[illegible]mena, he produced a number of the interesting results that ha[illegible] [illegible]ready made his name famous and have charmed two worl[illegible] [illegible] received, unhurt, currents of hundreds of thousands of volts, lit [illegible] tubes and lamps through his body, rendered insulated wires se[illegible] [illegible] feet long entirely luminous, showed a motor runni[illegible] [illegible] influence of these million-frequency currents, obtain[illegible] [illegible]mber of effects [illegible] [illegible] lamps. His ability [illegible] wire and no return [illegible]

bulb was lighted up by being merely held in the hand, and this was a most successful experiment. Mr. Tesla prefaced it by relating a little anecdote of Lord Rayleigh. When he was in London, remarked Mr. Tesla, with much feeling, he had the pleasure of performing this experiment privately before Lord Rayleigh, and he would always remember the trembling eagerness and excitement with which that distinguished scientist [illegible] lamp light up. The appreciation of such men, said Mr. Tesla, repaid him fully for the pains he had been at in working [illegible] these phenomena.

In this experiment a number of tubes were taken and flourished or flashed in various ways, and with the current made intermittent at longer intervals by adjusting the spark-gap. Wonderfully beautiful effects were thus produced, the light of the whirled tube being made to look like the white spokes of a wheel of glowing moonbeams. Then some rectangular tubes were taken and flashed or whirled so as to produce curious designs of luminous lines.

A bulb was shown by Mr. Tesla said by him to be so highly exhausted that when the bulb was merely attached to one terminal of the disruptive discharge coil, it would send the sparks across the outside of the globe to the other terminal, which was on the opposite end, rather than pass through the bulb. The bulb in question was painted on one side with a phosphorescent powder, or mixture, and threw a most dazzling light, far beyond that yielded by any ordinary phosphorescence. It was pointed out that there was no difficulty whatever in obtaining powerful phosphorescent effect in this way, and that a practical illuminant on these lines needed merely the perfection of the method of conversion above alluded to.

In conclusion the lecturer made fine cotton-covered wires stretched on a frame over the table luminous so that in the dark they looked like attenuated violet [illegible] yards long; and then within a large rectangle formed by such wires he flourished tubes in the interspace, these tubes flashing with light wherever waved.

After the lecture, so great was the desire of the public to see Mr. Tesla closer, an informal reception was held in the lobby when several hundreds of the leading citizens seized the opportunity and Mr. Tesla's hand in a very vigorous manner.

It should be added that the Electrical Exchange, of [illegible], presented Mr. Tesla at the beginning of the lecture with a magnificent floral shield, wrought in white carnations with a border of palms and American Beauty roses. It was about four feet in diameter. In the centre was a circle of red carnations bordering a tablet of white ones, bearing the letters in red C[illegible]

Around the circumference were the floral letters [illegible] Electrical Exchange 1898."

[illegible] Company's General Manager, Mr. [illegible], is leaving nothing undone to put within the easy reach [illegible]. Those who know his executive ability do not doubt his success and cheerfully credit him with highly useful and important pioneer work. The Company is also to be congratulated upon having such an able Superintendent as Mr. Henry [illegible], whose well known mechanical and engineering ability has put him in the front rank in the street railway field.

POWER TRANSMISSION.

TESLA ON ELECTRICITY WITHOUT WIRES.

Mr. Tesla thus writes the New York *Herald* under date Dec. [illegible]

In reply to your question as to what discovery would do most to better our condition, in my opinion the demonstration that the earth's electrical charge can be distributed, and thereby electrical waves efficiently transmitted to any distance without the use of cables or wires, would be the most beneficial.

The conveying of motive power from sources such as Niagara in this manner to any place, however remote, would increase many times the productive capacity of mankind. It would bring millions of miserable creatures from the darkness of the coal pits to the light of day. It would cause a kinder feeling to spring up

BRAKE COMPRESSOR.

[illegible] the strong, which would lead to a [illegible] adjustment of the evermore difficult questions of labor and capital.

Even if power could not be distributed, the mere transmission of intelligible signals would be of incalculable benefit. Such a realization would do away with the instability of the financial markets, which is the cause of much suffering and misery. It would greatly facilitate the evolution of noble ideas, as well as the prevention of evils. It would increase the safety of travel, give a new impetus to the press and spread of knowledge. [illegible] message transmitted would be the signal to general [illegible]ment and a closer union of nations, and the words of the [illegible] German poet, "Seid umschlungen, Millionen, diesen Kuss der ganzen Welt," would be deeply felt everywhere.

Our present knowledge is sufficient to fill us with the [illegible] that the solution of these important problems [illegible] May the new year witness these triumphs.

[illegible] CHLORATE OF POTASH AT NIAGARA.

[illegible] Rankine, of the Niagara Falls Power Company, has [illegible] that his company has made a contract with Walton Ferguson of New York City, under which Mr. Ferguson will erect a factory for the manufacture of chlorate of potash on the lands of the power company and use from 500 to [illegible] H. P. The site selected is to the east of the new calcic carbide plant and [illegible] acres of ground to start with. The buildings will be put [illegible]

Ricardo Zuloaga [illegible] has been at the Falls with Mr. W. B. Wreaks of the Westinghouse Electric and Manufacturing Company to view the power installation there. [illegible] is a member of the "Compania Anonima La [illegible]" of Caracas. This company has a project to d[illegible]

Legal Notice

[illegible]

AUTO-CARS.—By L. [illegible]. Trans. by [illegible] E. E. New York. Whittaker & Co. 1896. Cloth. 8vo. Illus. 240 pages. Price, $1.50.

This is a timely and interesting book, which we can cordially recommend to all interested in this important subject, about which information is so scarce. Much is written, but little is known. Indeed, a melancholy feeling comes over one in looking through these pages to note how many types are impossible, how many are too expensive, and how few combine inventive ideas with mechanical knowledge. Most of the automotors here shown will go into the scrap heap in a year or two, but the art will rear itself on their remains. The record is fairly complete in this volume, although, as it was first published in France it is not surprising to see several American machines electric and other, omitted from the enumeration.

LEGAL NOTES

THE TESLA PATENTS REVOKED IN GERMANY.

The Elektrotechnische Zeitschrift quoting the Köln. [illegible] states that the suit of the Allgemeine Elektricitäts-Gesellschaft of Berlin against the Aktien-Gesellschaft Helios of Cologne, for the revocation of the Tesla patents was tried before the German Patent Office and resulted in the revocation of the patents [illegible] 11 of the German Patent Laws. The case will be appealed to the Imperial Court by the Helios Company. Just what "Tesla patents" were revoked is not stated. The term is usually applied in [illegible] with induction motors requiring [illegible] phase currents for their operation.

The paragraph of the German Patent Law above referred to reads as follows:

[illegible] years, reckoned from the [illegible] publication of [illegible]

1. If the patentee fails to carry out his invention in Germany to a suitable extent or at least to do everything that is [illegible]

2. If the grant of license to others [illegible] appears to be demanded in the interest of public welfare, and the patentee nevertheless refuses to grant such license upon adequate compensation and against sufficient security.

WALKER CO. VS. GLENOAKS AND PROSPECT HEIGHTS RY. CO.—A SUIT FOR BREACH OF CONTRACT.

Mr. J. H. Gates, the Chicago representative of the Walker Company, of Cleveland, Ohio, informs us that they have begun an assumpsit suit for $15,000 against the Glen Oaks and Prospect Heights Railway Company, J. H. Seiberling, M. Seiberling, A. G. Seiberling and F. Pateo, all of Peoria, Ill., for breach of contract. It appears that the Walker Company contracted with the parties named for generators [illegible] and that the order was cancelled without any [illegible]. The Walker company are making a test case of this [illegible], and have engaged the services of several leading lawyers. It is said that a decision for the plaintiffs will put a [illegible] by some companies of ordering apparatus and then repudiating the contract even after the machinery has been built, but without [illegible]

[illegible] CONNECTICUT TROLLEY PARALLELS.

ON. GEORGE S. HALE, of [illegible] last week at his Bar Harbor cottage, was [illegible] R. S. Hale, the well known electrical and [illegible] whom deep regrets are felt at this heavy [illegible]

NEWS AND NOTES

TESLA ELECTRIFIES THE EARTH.

According to the New York "Journal," of August 4, Mr. Tesla announces the completion of his work for the transmission of messages from one point to another on the earth, without the aid of wires. To give an idea of the high potential currents used in this work, he showed a large disc, from the center of which protruded a spherical electrode shooting forth long streams of ethereal flame. Mr. Tesla stated that the electrical disturbance thus created was felt throughout the globe. The article is graphically illustrated with a [illegible] picture of the contrivance for emitting the discharge.

THE STOCK MARKET

RANSMISSIO[illegible]

TESLA'S HIGH POTENTIAL TRANSFORMER.

I[illegible] experiments involving high potentials [illegible] Nikola [illegible] of induction coil, and in a recent patent issued to him he de-scribes several forms specially adapted to be used in connec-tion with a system of high potential power transmission. To accomplish the desired object Mr. Tesla employs an induction coil or transformer in which the primary and secondary [illegible] are wound in such manner that the convolutions of the con-ductor of the latter will be farther removed from the pri-mary as the liability of injury from the effects of potential increases, the terminal or point of highest potential being the [illegible], and so that between adjacent convolutions there [illegible] be the least possible difference of potential.

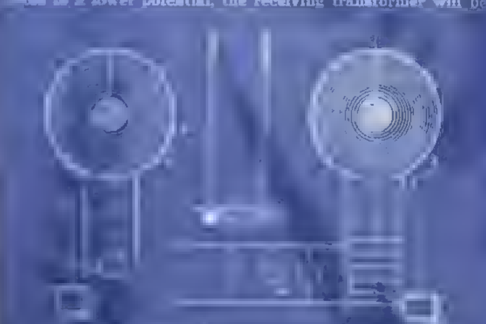
The type of coil in which the last named features are pres-ent is the flat spiral, and this form Mr. Tesla generally em-[illegible] winding the primary on the outside of the secondary and taking off the current from the latter at the center or in-[illegible] end of the spiral.

In constructing his improved transformers Mr. Tesla em-ploys a length of secondary which is approximately one-quar-ter of the wave length of the electrical disturbance in the cir-cuit including the secondary coil, based on the velocity of pro-pagation of electrical disturbances through such circuit, or, in general, of such length that the potential at the terminal of the secondary which is the more remote from the primary shall be at its maximum. In using these coils the inventor connects [illegible] end of the secondary, or that in proximity to the primary, [illegible] earth, and in order to more effectually provide against in-jury to persons or to the apparatus he also connects it with the primary.

The accompanying diagram, Fig. 1, illustrates the plan of winding and connection employed in constructing the improved coils and the manner of using them for the transmission of [illegible] over long distances.

A designates a core, which may be magnetic, around which [illegible] coil B is wound in spiral form. C is the primary, which [illegible] wound around in proximity to the secondary. One terminal [illegible] the latter will be at the center of the spiral coil, and from [illegible] the current is taken to line. The other terminal of the [illegible] is connected to earth and also to the primary.

[illegible] two coils are used in a transmission system in which [illegible] currents are raised to a high potential and then recon-[illegible] to a lower potential, the receiving transformer will be



[illegible]ENTIAL TRANSMI[illegible]

[illegible] connected in the same manner [illegible] the inner or center end of what corresponds to [illegible] of the first will be connected to line and the [illegible] to earth and to the local circuit or that which cor-responds to the primary of the first. In such case also the line [illegible] should be supported in such manner as to avoid loss by [illegible] current jumping from line to objects in its vicinity and [illegible] contact with earth—as, for example, by means of long in-[illegible], mounted, preferably, on metal poles, so that in case of leakage from the line it will pass harmlessly to earth. In [illegible], where such a system is illustrated, a dynamo G [illegible]

[illegible] POWER TRANSMISSION

TESLA'S HIGH POTENTIAL TRANSFORMER.

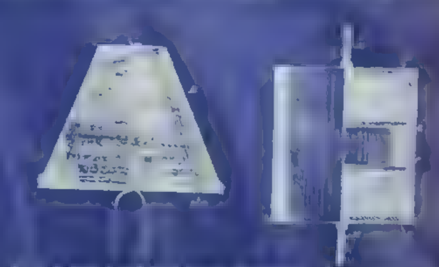
resented as supplying the primary of the sending or [illegible] transformer and lamps H and motors K are shown as connect-ed with the corresponding circuit of the receiving or "step-down" transformer.

Instead of winding the coils in the form of a flat spiral the [illegible] may be wound on a support in the shape of a frus-tum of a cone and the primary wound around its base, [illegible] shown in [illegible]

In practice for apparatus designed for ordinary usage the coil is usually constructed on the plan illustrated in Fig. [illegible] In this figure L L are spools of insulating material upon which the secondary is wound—in the present case, however, in two sections, so as to constitute really two secondaries. The pri-mary C is a spirally-wound flat strip surrounding both secon-daries B. The inner terminals of the secondaries are led out through tubes of insulating material M, while the other or out-side terminals are connected with the primary.

The length of the secondary coil B or of each secondary coil when two are used, as in Fig. 3, is, as before stated, approxi-mately one-quarter of the wave length of the electrical dis-turbance in the secondary circuit, based on the velocity of pro-pagation of the electrical disturbance through the coil itself and the circuit with which it is designed to be used—that is to say, if the rate at which a current traverses the circuit including the coil, be 185,000 miles per second, then a fre-quency of 925 per second would maintain 925 stationary waves in a circuit 185,000 miles long, and each wave length would be 200 miles in length. For such a frequency Mr. Tesla would use a secondary 50 miles in length, so that at one terminal the potential would be zero and at the other maximum.

Coils of this character, according to Mr. Tesla, [illegible]



[illegible]RMER.

[illegible] number of turns the difference of potential between adjacent turns is comparatively small, and hence a very high potential, impracticable with ordinary coils, may [illegible] As the secondary is electrically [illegible] primary the latter will be at [illegible] as the adjacent portions of the secondary [illegible] be no tendency for sparks to jump from [illegible] destroy the insulation. Moreover, as [illegible] dary are grounded and the line [illegible] carried and protected to a point remote from the apparatus [illegible] a discharge through the body of a person [illegible] approaching the apparatus is reduced to a minimum.

TESTING THREE-PHASE INDUCTION MOTORS—TRANS-FORMER CONNECTIONS [illegible]

[illegible] the latter will be at the center of the spiral coil, and from [illegible] The other terminal of the secondary is connected to earth and also to the primary.

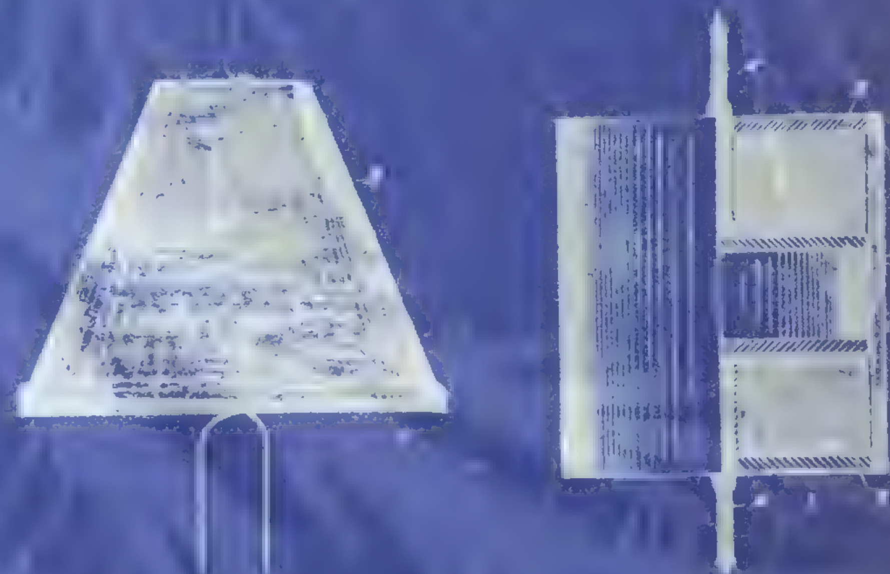
When two coils are used in a transmission system in which the currents are raised to a high potential and then reconverted to a lower potential, the receiving transformer will be

FIG. [illegible].—TESLA HIGH POTENTIAL TRANSMISSION SYSTEM.

constructed and connected in the same manner as the first—that is to say, the inner or center end of what corresponds to the secondary of the first will be connected to line and the other end to earth and to the local circuit or that which corresponds to the primary [illegible] manner as to avoid loss by

and the circuit with which it is designed to be used—that is to say, if the rate at which a current traverses the circuit including the coil be 185,000 miles per second, then a frequency of 925 per second would maintain 925 stationary waves in a circuit 185,000 miles long, and each wave length would be 200 miles in length. For such a frequency Mr. Tesla would use a secondary 50 miles in length, so that at one terminal the potential would be zero and at the other maximum.

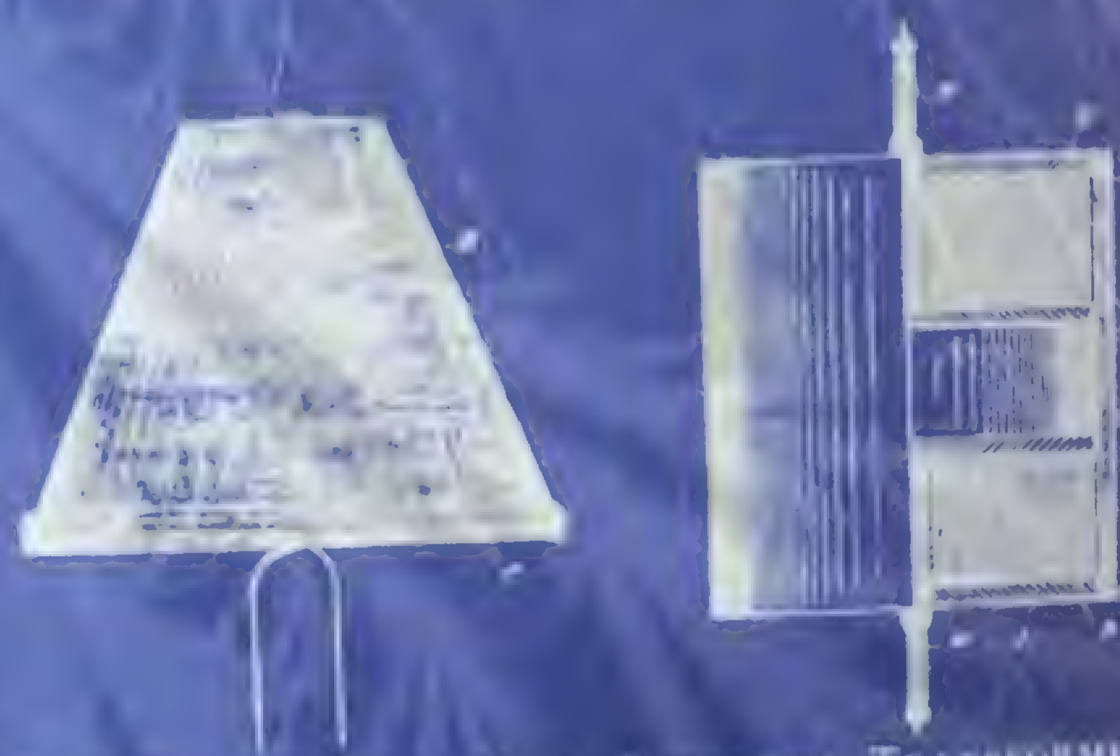
Coils of this character, according to Mr. Tesla, have severa



FIGS. 2 AND 3.—TESLA HIGH POTENTIAL TRANSFORMERS.

important advantages. As the potential increases with the number of turns the difference of potential between adjacent turns is comparatively small, and hence a very high potential, impracticable with ordinary coils, may be successfully maintained. As the secondary is electrically connected with the primary the latter will be at substantially the same potential

including the coil, be 185,000 miles per second, then a fre-
quency of 925 per second would maintain 925 stationary waves
in a circuit 185,000 miles long, and each wave length would be
200 miles in length. For such a frequency Mr. Tesla would
use a secondary 50 miles in length, so that at one terminal the
potential would be zero and at the other maximum.
Coils of this character, according to Mr. Tesla, have several



FIGS. 2 AND 3.—TESLA HIGH POTENTIAL TRANSFORMERS.

... As the potential increases with

[illegible] four hours per day [illegible] of two hours each [illegible] which permits the changing of the [illegible]

MR. TESLA ON X-RAY BURNS.

[illegible] be considered a rule of nature that every beneficent [illegible] of force may be accompanied by deleterious [illegible] guarded against by suitable precautions. [illegible] Röntgen ray is no exception to the rule. [illegible] in this field noted a harmful action of the r[illegible] the skin, but of late instances have been reported [illegible] injury due to so-called X-ray burns. It is probable [illegible] the cases mentioned are due [illegible] to neglect or impro[illegible] treatment of the injury than to the original effect [illegible] "burn;" nevertheless, it is eminently [illegible] sible means be adopted for the preven[illegible] gin with, on the old principle that an ounce [illegible] better than a pound of cure. Mr. Nikola [illegible] done as much X-ray work as any one [illegible] whose sheer power has probably not been exceeded by that [illegible] worker in this field and invariably without harmful [illegible] certain precautions were taken. The means [illegible] its, and their raison-d'être, a[illegible] communication appearing in [illegible] porary, The Electrical Review.

[illegible] prevention of X-ray burns Mr. Tesla finds that [illegible] as to interpose between the bulb and the per[illegible] sheet of aluminum or aluminum wire gauze, con[illegible]nected to the ground directly or through a condenser. This [illegible] according to Mr. Tesla, prevents the formation of [illegible] static streamers, which would otherwise issue from the body, and which have an irritating effect. In the course of his experiments, Mr. Tesla observed, however, that the injurious effects did not seem to diminish gradually with the distance from the terminal, but ceased abruptly. He a[illegible]ounts for this as due to the effect of the ozone generated, and supports this view by the fact that the generation of ozone ceases at a definite distance from the terminal.

[illegible] perhaps the most striking fact developed by Mr. Tesla [illegible] investigations is, that bulbs containing platinum electrodes are more injurious that those provided with alu-

[illegible] THE ELECTRIC [illegible]

[illegible] am [illegible]

[illegible] physic[illegible] fact that [illegible] health may [illegible] of a trouble[illegible] person [illegible] brought close[illegible] produced when [illegible] as the X-ra[illegible]

[illegible] Tesla has not [illegible] grated cathode[illegible] stands practically [illegible] theory of the [illegible] seems to be gro[illegible] ments multiply [illegible]

FALSE TEACHERS.

American Florist Nov. 17, 1898 p 481

... during the operation of inserting ... the tool and attaching the clamps to ...

of the area to which it is to be applied. The vessel—in this instance a boat—is provided with [illegible] propelling machinery, which is shown as comprising a screw propeller C, secured to the shaft of an electromagnetic motor D, which derives its power from storage batteries E E E E. In addition to the propelling engine or motor the boat carries also a small steering motor F, the shaft of which is extended beyond its bearings and provided with a worm which meshes with a toothed wheel G. This latter is fixed to a sleeve b, freely movable on a vertical rod H, and is rotated in one or the other direction, according to the direction of rotation of the motor F.

The sleeve b on rod H is in gear, through the cog-wheels H′ and H″, with a spindle G, mounted in vertical bearings at the stern of the boat and carrying the rudder F′.

The apparatus by means of which the operation of both the

Fig. 1.

propelling and steering mechanisms is controlled [illegible] receiving circuit, adjusted and rendered sensitive to the [illegible] of waves or impulses emanating from a remote source, the adjustment being so that the period of oscillation of the circuit [illegible] either the same as that of the source or a harmonic thereof.

[illegible] receiving circuit proper (diagrammatically shown [illegible]) comprised a terminal E′, conductor C′, a sensitive [illegible] a conductor A′, leading to the ground connection [illegible] connection to the metal keel [illegible] of the vessel. The [illegible] should present a large conducting surface and should [illegible] as high as practicable on a standard D′, which is [illegible] broken in Fig. 2; but such provisions are not always [illegible]. It is important to insulate very well the conductor [illegible] manner it be supported.

[illegible] circuit or path just referred to forms also a part of [illegible] which latter includes a relay magnet [illegible] and a battery [illegible] electromotive force of which is, as [illegible] though the dielectric layers in the [illegible] subjected to a great strain, yet normally [illegible] and no appreciable current [illegible] when an electrical disturbance [illegible] films are broken down [illegible] suddenly and greatly [illegible] the relay magnet [illegible]

[illegible] device employed [illegible] insulating heads, through [illegible] A small quantity of [illegible]

[illegible]

equal conductivity of their surfaces and stops [illegible] deterioration, thus preventing a change in the character [illegible] in the space in which they are enclosed. He prefers not to rarefy the atmosphere within the sensitive device, as this has the effect of rendering the former less constant in regard to its dielectric properties, but merely secures an [illegible] absence of moisture [illegible] factory working.

The normal position of the cylinder [illegible] turned in the manner described, the [illegible] shifted from one end to the other [illegible] fall through the same space [illegible] tion they are brought [illegible] precisely the same elec[illegible]

[illegible]

[illegible] tive while the brush j′ [illegible] upon [illegible] the plates j′ and j″. While [illegible] on to throw the rudder to port. On the [illegible]

[illegible] circuits, however [illegible] obvious purposes.

[illegible] introduction of [illegible] from his laboratory in [illegible] of the Paris Expo[illegible] that he does not [illegible] idea beyond that [illegible] been made familiar [illegible]

The reporters who have been allowed to [illegible] state that Mr. Tesla has there a model [illegible] torpedo boat on stocks, the keel of copper [illegible]

[illegible]

[illegible]

22222222222

through a connection to the metal keel [illegible] of the vessel. The [illegible] be supported as high as practicable on a standard D', which [illegible] shown as broken in Fig. 1, but such provisions are not always necessary. It is important to insulate very well the conductor [illegible]

The circuit or path just referred to forms also a part [illegible] local circuit, which latter includes a relay magnet a and a b[illegible] a', the electromotive force of which is, as before explai[illegible] determined that although the dielectric layers in the [illegible]vice A' are subjected to a great strain, yet no [illegible] the strain and no appreciable current flows [illegible] local circuit; but when an electrical disturbance reaches t[illegible] the dielectric films are broken down, the resistance of device A' is suddenly and greatly diminished, and a current traverses the relay magnet A.

The particular sensitive device employed consists of a metal cylinder with insulating heads, through which passes a central [illegible] such as an oxidized metal, is placed in the cylinder. A metallic strip, secured to an insulated point, bears against the side of the [illegible] rod is connected to the frame of the instrument and so to the other part of the circuit. This instrument, which is similar in [illegible]

To do away with the defects in the sensitive device, Mr. T[illegible] the particles by a special tool, insuring their equality [illegible]

apparatus for pro[illegible]

p. 486

[illegible]

[illegible] Arc Lights

INQUIRY having been made of us [illegible] [illegible] [illegible] based, we may say with reference to that interesting and important subject, that the agreement was entered into last [illegible] and runs for ten years, as already noted in our columns. It provides for the use of enclosed arc lights of 2,000 c. p. and the [illegible] as follows:

Number of lights.		
[illegible] than 2,305 nor more than 2,749	[illegible]	[illegible]
" 2,750 " " " [illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

This scale is subject to submission to arbitrators and to [illegible] in favor of the city from time to time, if investigation shows the [illegible] be capable of reduction, due allowance being made for not less than 7 per cent. for depreciation and 3 per cent. for fixed charges. These arbitrators have the ability to force on the company the adoption of any new system or device that shall have shown itself useful as a means towards the reduction of [illegible].

[illegible] a notable and remarkable contract, breathing [illegible] [illegible]ty, and embodying to the full all those modern [illegible] regard corporations no longer as bodies of men [illegible] for purposes of mutual profit [illegible] servitors of the [illegible] and fostered [illegible] State can de[illegible] [illegible]

[illegible] on a commercial basis of the lights furnished by the [illegible]nicipal plant in Chicago, is very fair to all parties. The prices are considerably higher than the prices charged by the Missouri Edison Co., of St. Louis, and the Cincinnati Edison Co., and slightly higher than those charged in Baltimore by a new competing company for park lights. The summary comes out as follows:

SUMMARY

Boston (average price)	[illegible]
Detroit municipal plant (on commercial basis)	[illegible]
Chicago municipal plant (on commercial basis)	[illegible]
Chicago (company) (underground contract)	[illegible]
Chicago (company) (overhead contracts)	[illegible]
St. Louis	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible] (average price)	[illegible]
New York	[illegible]

Of course, in preference to this equitable and surely satisfactory contract, Boston might have put in its own plant after [illegible] through the conditions required by law, but it has most wisely decided not to venture into that uncertain investment. It finds warrant for such decision in some figures compiled recently by Alderman Wesley Sears, of Jackson, Mich., and pre[illegible] in the October issue of "City Government," a journal which has certainly no bias towards private companies. Mr. Sears tried hard to get all the data he could about municipal plants, and he gives a lot of it, but the comments that [illegible] are even more interesting and striking than the figures. [illegible] ample, Bloomington, Ill., says: "We figure no [illegible] neither do we figure interest, because [illegible] a fool's paradise those city officials must live in. [illegible] "We do own our light [illegible] if not, we would not, for in my opinion it [illegible]." Michigan City, Ind., says: "The time [illegible] electric light plant, it [illegible] connection with our waterworks, it was run very [illegible], and the plant had run down. Our council thought it best to sell. We got $3,000 for same. Think original cost was $[illegible],000 [illegible] and so it goes.

Mr. Tesla [illegible]

THE personality of Mr. [illegible] in the field of modern [illegible] command the interest [illegible] whenever he [illegible] researches [illegible] and practice [illegible] useful above [illegible] of his other [illegible] in electricity [illegible] number [illegible] Prof. [illegible]

into the dazzling theories and speculations associated with his name. That he should desire to benefit the human race in [illegible] [illegible] or a score of later generations [illegible] find fault either with the Czar or with Mr. Tesla? Their aims appear wholly noble, their thoughts are beautiful, and if they fail, as they probably will in some material and vital respects, the world is certainly none the worse off for what they actually accomplish.

[illegible] of late Mr. Tesla has been giving publicity to some of his newest work, and it is peculiarly interesting. We should have been glad, personally, to see him finish up some of the [illegible] things that have occupied his energies these ten years [illegible] of which now claim any place. For example, his [illegible] combination of generator and steam engine, [illegible] wipe out all other methods of power generation [illegible] the cost of power, by steam and electric [illegible] name is now bestowed by Mr. Tesla on [illegible], and though illustrated in detail and [illegible] Chicago Electrical Congress in 1893, the [illegible] brand is, for aught the public knows, [illegible] was a lovely invention, of infinite [illegible] its neglect and oblivion, but if Mr. Tesla has other things more appealing to his mind for the present, that is his own business.

Of late also Mr. Tesla has brought forward another [illegible] power generation and transmission. At one period he expressed his belief in ability to disturb the earth's charge and thus send currents through the earth. That does not appear to be so feasible or attractive now as the idea of using the upper strata of the air which he says have a very superior conductivity. He would [illegible] up aloft balloons in those strata and deliver to them large [illegible] of current at such high potential that it would travel [illegible] across the space without wires, say from Niagara [illegible] to Paris. By this facile distribution of water power [illegible] [illegible] Tesla may have some [illegible] [illegible] and sustentation purposes. It will be remembered [illegible] Marconi has already [illegible] wires, a distance of over twenty miles, thus proving in advance the tenability of Mr. Tesla's proposition.

The tremendous hold that war has taken upon the public [illegible] [illegible] invention in that [illegible] estimates that he believes [illegible] pedo boats which were so utterly useless [illegible] the late conflict with Spain [illegible] trolled entirely from shore, by a Navy Board, and without any crew. Last spring the ability to explode floating torpedoes under ships from a distance without any wires [illegible] demonstrated at Madison Square Garden [illegible] for a month. Taking that idea, Mr. [illegible] steering of torpedoes [illegible] [illegible]

[illegible] finished lecture two years ago [illegible] [illegible] ments [illegible] are they. But [illegible] means and instrum[illegible] physician, and it is [illegible] the slaughter due to [illegible] this brilliant [illegible] [illegible] matter. All we wish [illegible] so many do, Mr. Tesla as visionary [illegible] has finished his work till he is dead, and [illegible] long, long centuries in which his ideas [illegible] of realis[illegible]

[illegible]

[illegible] paper read before the [illegible] [illegible] at St. Louis, by Capt. [illegible] [illegible] ago. [illegible] [illegible] immediate [illegible] last week by [illegible] city, caused [illegible] at the time [illegible] were in the build[illegible] [illegible] emptied the [illegible]

[illegible] needed, that [illegible] of patriotism [illegible] carried [illegible] [illegible] independent [illegible]

[illegible] of apparatus, and though illustrated in detail and [illegible] before the Chicago Electrical Congress in 1893, the [illegible] of the original brand is, for aught the public knows, in the scrap heap. Yet it was a lovely invention, of infinite possibilities. We can only regret its neglect and oblivion, but if Mr. Tesla has other things more appealing to his mind for the present, that is his own business.

Of late also Mr. Tesla [illegible] power generation and transmission. At [illegible] his belief in ability to disturb the earth's charge and thus send currents through the earth. That does not appear to be so feasible or attractive now as the idea of using the upper strata of the [illegible] and deliver to them large [illegible] ntial that it would travel [illegible] res, say from Niagara [illegible] le distribution of water power, coal [illegible] ould become unnecessary to industry. [illegible] lain why Mr. Tesla [illegible] be hoped that this novel [illegible] prove workable. Balloons were a dismal failure in our late [illegible] but that is no criterion, and Mr. Tesla may have [illegible] gas for inflation and sustentation purposes. It [illegible] bered that Mr. Marconi has [illegible] proving in advance the tenabili [illegible]

[illegible]

[illegible] the ability to explode floating torpedoes [illegible] distance without any wires was brilliantly [illegible] Madison Square Garden several times a day [illegible] months [illegible] that idea Mr. Tesla has applied the same principle to the electro-mechanical steering of tor[illegible] is now done with [illegible] [illegible] from [illegible]

[illegible] print in [illegible] issue of the [illegible] of his on existing [illegible]

[illegible] open [illegible] around the ships, the [illegible] national explosion of defenses pla[illegible] and [illegible] its operation [illegible] less sensitive than [illegible] the heavy [illegible] ough coher[illegible]

THE

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[INCORPORATED.]

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Mr. Tesla to His Friends.

New York, Nov. 18, 1898.
46 and 48 East Houston St.

Editor of The Electrical Engineer, 120 Liberty St., New York City.

Sir—By publishing in your columns of Nov. 17 my recent contribution to the Electro-Therapeutic Society you have finally succeeded—after many vain attempts made during a number of years—in causing me a serious injury. It has cost me great pains to write that paper, and I have expected to see it appear among other dignified contributions of its kind, and, I confess, the wound is deep. But you will have no opportunity for inflicting a similar one, as I propose to take better care of my papers in the future. In what manner you have secured this one in advance of other electrical periodicals who had an equal right to the same, rests with the secretary of the society to explain.

Your editorial comment would not concern me in the least, were it not my duty to take note of it. On more than one occasion you have offended me, but in my qualities both as Christian and philosopher I have always forgiven you and only pitied you for your errors. This time, though, your offence is graver than the previous ones, for you have dared to cast a shadow on my honor.

No doubt you must have in your possession, from the illustrious men whom you quote, tangible proofs in support of your statement reflecting on my honesty. Being a bearer of great honors from a number of American universities, it is my duty, in view of the slur thus cast upon them, to exact from you that in your next issue you produce these, together with this letter, which in justice to myself, I am forwarding to other electrical journals. In the absence of such proofs, which would put me in the position to seek redress elsewhere, I require that, together with the preceding, you publish instead a complete and humble apology for your insulting remark which reflects on me as well as on those who honor me.

On this condition I will again forgive you; but I would advise you to limit yourself in your future attacks to statements for which you are not liable to be punished by law.

N. TESLA.

His Friends to Mr. Tesla.

ONE of the foremost electrical inventors of this co[illegible] whose name is known around the world, has been [illegible] enough to say that The Electrical Engineer made Mr. Tesla. This is an attribution that we naturally put aside, for it is a man's own work that makes or unmakes him, but we do plead guilty to the fact that for these ten years past we have done whatever mortals could do to bring Mr. Tesla forward and secure for him the recognition that was duly his. Not only in the columns of this and other journals, but in magazines and books we have striven with all the ability we possessed to explain Mr. Tesla's ideas. The record is before all men. If there is a line or a word in it that seeks to do Mr. Tesla "serious injury," we demand its production by him. The man, whoever he be, who says we have ever in word or deed or thought tried to do Mr. Tesla any sort of injury, lies.

Within the last year or two Mr. Tesla has, it seems to us, gone far beyond the possible in the ideas he has put forth, and he has to-day behind him a long trail of beautiful but unfinished inventions. By mild criticism and milder banter, not being able to lend Mr. Tesla the cordial support of earlier years of real achievement, we have only very lately endeavored to express our doubts and to urge him to the completion of some one of the many desirable or novel things promised. We believe this to be true friendship.

For example, take Mr. Tesla's latest and furthest enlargement of his newest idea, as presented by him in a signed letter in the New York "Sun," of Nov. 21, unfolding his plan to dispense with artillery of the present type. At this moment we have space only for the following passage:

"We shall be able, availing ourselves of this advance, TO SEND A PROJECTILE, at much greater distance, IT WILL NOT BE LIMITED IN ANY WAY BY WEIGHT or amount of explosive charge, we shall be able to submerge it at command, TO ARREST IT IN ITS FLIGHT AND CALL IT BACK, and to send it out again and explode it at will, and, more than this, IT WILL NEVER MAKE A MISS."

When we are expected, wide awake and in our sober senses, to accept in silence such an utterance as that quoted above or that which describes as "a possibility" the operation of a distant torpedo boat by the mere exercise of the will, we refuse point blank and we are willing to face the consequences. Our past admiration of Mr. Tesla's real, tangible work is on record, and stands; but we draw the line at such things as these. We are sorry Mr. Tesla feels it so keenly, but we cannot help it.

Now, as to the specific points raised in the above letter, which Mr. Tesla certainly would not have written had he been well advised. As to the manner in which we came to print Mr. Tesla's paper, the two letters herewith speak for themselves.

The American Electro-Therapeutic Association.
Dr. Charles R. Dickson, Ex-President.
296 Sherbourne St.
Toronto, Canada, Sept. 26, 1898.

T. Commerford Martin, Esq., 120 Liberty St., New York.

Dear Sir—I was quite surprised to hear on Saturday last from my friend, Dr. Robert Newman, of New York, that the editors of The Electrical Engineer had received no notices of the meeting of our association; I understood that the secretary had sent them. However, in case you might find space to say something of us, I have patched up an article drawn from various sources giving full particulars, which you can cut down to the desired dimensions. I fully appreciate all that you have done for the association in the past, or would not go to this trouble. I also send you a copy of the programme and of hand-book. In regard to latter, I am very sorry that the Buffalo committee had to retain for such a long time the electro of Mr. Tesla which you were so kind as to loan to them through Dr. Newman.

I have to thank you very sincerely for the loan of the electro, and hope that it reached you in good condition.

Wishing your esteemed journal continued and increasing success, very truly yours, CHARLES R. DICKSON.

The American Electro-Therapeutic Association.
Dr. Robert Newman, Chairman.
64 West 36th St.
New York City, Oct. 20, 1898.

Messrs. T. C. Martin and J. Wetzler.

Messrs. Editors—We have now the necessary vote for you publishing Tesla's paper in The Electrical Engineer, you lending us the cuts in proper size for our transactions.

The pages of our book are 7½ by 5 inches—if our secretary is not dilatory, you will receive the mss. and illustrations at once. Will call soon. Yours most truly, ROBERT NEWMAN.

These show our relations with a deserving association and our efforts to assist its work. We may add as a matter of fact, for which, if necessary, the proofs will be presented, that before printing the paper, we sent Dr. Newman to technical publishers, who refused to print the matter in book form because there was not, in their estimation, sufficient demand for it among scientific men. Failing this, we were undoubtedly glad to give it a place in our pages, as it struck us as good "copy."

We venture also to direct attention to the dates of the Dickson and Newman letters, one Sept. 26 and the other Oct. 20. The Tesla paper was read on Sept. 15 and appeared in our columns Nov. 17. Does this gap of over two months between reading and publication justify Mr. Tesla's insinuation that we took swift and mean advantage of him and of our contemporaries? Will anyone produce a letter to show that anyone of our contemporaries ever took the slightest interest in the Tesla paper or even asked for it? If such letters exist, now is the time to produce them. The paper was given to The Electrical Engineer because this journal takes a deep interest in the advance of electro-therapists and has a wide circulation among them, and according to universal custom, the paper once read became the property of the association to deal with as it chose. That, without any particular effort, we should have secured a "scoop"—to use the slang of journalism—is nothing to be ashamed of; we rather glory in it, for whatever it is worth.

It will be noted that we placed freely at the disposal of the association a portrait block of Mr. Tesla which we value highly. We were anxious, however, to do him honor in this way, and loaned the original. Since that time, we have loaned it, without charge, to Mr. Belford, of "Success," in whose November issue it appears by our courtesy; and we have within the past week placed it at the disposal of another publishing house. Perhaps these are the attempts to do him an injury about which Mr. Tesla has so unfortunately allowed himself to be persuaded.

Now as to the very depreciatory quotations from the distinguished scientists, Profs. Brackett and Dolbear. The passage from Prof. Brackett appeared in the New York "Herald" of Nov. 9. That from Prof. Dolbear appeared in the New York "Herald" of Nov. 10. They had not been contradicted or withdrawn when we called attention to them and objected to them. One of our electrical contemporaries last week quoted them both like ourselves, but said it was inclined to agree with Prof. Dolbear. We now beg to call Mr. Tesla's attention to the subjoined dispatches from both scientists, and would say that having already expressed dissent from the views of both Profs. Brackett and Dolbear, we do not see how it concerns us any further.

(Press Telegram.)

Princeton, N. J., Nov. 20, 1898.

T. C. Martin, Editor of The Electrical Engineer, New York.

Some of the language on pages 490 and 491 of The Electrical Engineer of Nov. 17, purporting to be quoted from me, is a fairly correct reproduction of what I said to a "Herald" reporter in reply to his question as to the probable practicability of Mr. Tesla's device for the abolishing war already presented in the "Herald," a copy of which he showed me.

In the language which you quote, there is much confusion and inaccuracy, due to the fact that the reporter took no notes of what I said, but trusted his memory.

No subject other than that proposed, viz.: Is the proposed plan practicable, was discussed. C. F. BRACKETT.

North Cambridge, Mass., Nov. 21.

The Electrical Engineer, New York.

Letter received this morning. The "Herald" report was substantially accurate. I will write more to you presently.

A. E. DOLBEAR.

"Greatest Discovery of the Age."

Mr. H. W. Phillips, in the "Criterion" of Nov. 19, has an illustrated interview with Mr. Tesla, whom he quotes as follows in regard to his use of the coherer as a relay for steering dirigible torpedoes: "I think that it is the greatest discovery of the age. There is something artistic—an appeal to the imagination—in it that the telephone, phonograph and other fine inventions lack." In reply to an inquiry as to his ability to operate the coherer by an effort of the will merely, Mr. Tesla said to Mr. Phillips: "I have no evidence to support it, but I have a perfect right to state it—understand me—as a possibility—no more." Mr. Tesla also remarked: "Had I nothing else to show for a lifework, this would put the laurels of everlasting fame on my head."

The Evolution of the Surface Contact Railway.

THE sudden, swift and tremendous development of the open conduit railway system must have arrested the attention of every one who takes notice of electro-mechanical advance. Up to within the last year or two it seemed as though that method of traction would not operate successfully and economically in our American cities. Every trial resulted in utter failure in regard to convincing street railway managers that it was what they wanted. Now a change has come, and in New York nothing but the open conduit trolley has for the present the ghost of a chance; while many other cities bid fair soon to fall in line. Having fought hard for the overhead trolley, we can say that we welcome heartily this wonderful broadening out of the traction art, enabling electricity to capture the metropolis that was so long denied to it.

But is the end yet? Why need a conduit be open? Why must there be a couple of extra gutters in the street with bare exposed electrical conductors in them? We believe firmly that there is no final reason; but that the next step is some form of sealed conduit, or surface contact, system. Every indication points that way, and it is for this reason that we are glad to give space to the paper on this subject by Mr. E. H. Johnson, read last week before the New York Electrical Society. It must be remembered that he does not stand alone in his advocacy of the new departure. Both the Westinghouse and the General Electric companies have adopted sealed conduit systems, and reports of others come thickly from across the Atlantic. Such signs cannot well be mistaken.

As to the merits of the Johnson-Lundell system, it is hardly within our province to pronounce a judgment yet, but we wish it the fullest success. It has a great many good points, and it has behind it a man who despite the ardor of his enthusiasm has never yet backed a failure. Mr. Johnson ties to realities and builds up concrete successes, and it will be strange indeed if in the near future he does not see all his hopes as to surface contact railways realized to the fullest degree.

A New Electric Railway on Manhattan Island.

A certificate incorporating the Fort George Extension Railway Company, of New York City, with a capital of $10,000, was filed with the Secretary of State on Nov. 17. The company purposes to operate an electrical surface road from 172d to 185th street, on Eleventh avenue. Its directors are M. G. Starrett, W. P. Plummer, John Lambden, Andrew Loughlin, D. W. Patterson and Harry Hartwell, of New York City; John Kerr and Charles E. Corby, of Brooklyn, and H. A. Himely, of Far Rockaway.

plants, and to make them blossom as the rose, will be watched with the utmost interest and good will, and should prove that electricity not only abhors a desert, but abolishes it.

Mr. Tesla's New Theory of Artificial Light.

EVER since Mr. Tesla practically finished his multiphase motor work, now more than ten years ago, he is understood to have devoted much of his time to experimental work in the domain of electric lighting. His first attempts led him in the direction of the vacuum tube and his brilliant lectures on that subject, both here and abroad, must still be fresh in the minds of many of our readers. But even in those lectures Mr. Tesla devoted considerable space to the discussion of the employment of solid, refractory materials as light giving media under the influence of high frequency currents. It would seem, however, that of late Mr. Tesla has greatly modified his views as to what is a sine qua non in a successful electric illuminant. At least we are led to this belief after reading an interview had with him by Mr. Charles Culver Johnson, appearing in the "Philadelphia Press." We must confess at the outset that we are unable to follow the interviewer at all points, but we gather in general that Mr. Tesla has come to the conclusion that electricians have all been on the wrong track in the past in working on so-called non-refractory or heat proof materials as light giving bodies. There are, Mr. Tesla says, a few bodies which for a time seem to be indifferent to heat, but he has found that not one of them will endure a continuous strain. In this new discovery, we are told, vibrations play a most important part, Mr. Tesla having succeeded in obtaining more perfect control of the more rapid vibrations of light waves. Carbon is not employed as the light giver. As to the nature of the force employed the interviewer quotes Mr. Tesla as saying that he "will form an electric circuit and then with a file reduce the thickness of the wire a sixteenth of an inch and double the force of the current." The details of Mr. Tesla's work in this direction are unfortunately lacking, but Mr. Tesla promises to prepare a paper on the subject, "which he will read presently to a few scientific friends." Failing full details the information thus far vouchsafed is insufficient to permit of much comment, but we are glad to know that we may so soon expect a promised advance in electric lighting. All such work as this, or, in older directions, such as that on the Nernst lamp, is worthy of fullest encouragement.

Electric Stairways.


VIEUX
CARRÉ
ABSINTHE
SUPÉRIEURE
120 PROOF
60% ALC/VOL
GRAB
A BEER